The Caribbean Forester

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Caribbean Forester

El "Caribbean Forester", revista que el Servicio Forestal del Departamento de Agricultura de los Estados Unidos comenzó a publicar trimestralmente en julio de 1938 es de distribución gratuita y está dedicada a encauzar la mejor ordenación de los recursos forestales de la región del Caribe. Su propósito es estrechar las relaciones que existen entre los científicos interesados en la Ciencia Forestal y ciencias afines encarándoles con los problemas confrontados, las políticas forestales vigentes y el trabajo que se viene haciendo para lograr ese objetivo técnico.

Se solicita aportaciones de no más de 20 páginas mecanografiadas. Deben ser sometidas en el lenguaje vernáculo del autor, con el título o posición que este ocupa. Es imprescindible incluir un resumen conciso del estudio efectuado. Los artículos deben ser dirigidos al "Director, Tropical Forest Experiment Station, Río Piedras, Puerto Rico."

Las opiniones expresadas por los autores de los artículos que aparecen en esta revista no coinciden necesariamente con las del Servicio Forestal. Se permite la reproducción de los artículos siempre que se indique su procedencia.

The "Caribbean Forester", published since July 1938 by the Forest Service, U. S. Department of Agriculture, is a free quarterly journal devoted to the encouragement of improved management of the forest resources of the Caribbean region by keeping students of forestry and allied sciences in touch with the specific problems faced, the policies in effect, and the work being done towards this end through out the region.

Contributions of not more than 20 typewritten pages in length are solicited. They should be submitted in the author's native tongue, and should include the author's title or position and a short summary. Papers should be sent to the Director, Tropical Forest Experiment Station, Río Piedras, Puerto Rico.

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Le "Caribbean Forester", qui a été publié depuis Julliet 1938 par le Service Forestier du Département de l'Agriculture des Etats-Unis, est une revue trimestrielle gratuite, dediée à encourager l'aménagement rationnel des forêts de la region caraibe. Son but est d'entretenir des relations scientifiques entre ceux qui s'interéssent aux Sciences Forestières, ses problèmes et ses méthodes les plus récentes, ainsi qu'aux travaux effectués pour réaliser cet objectif d'amelioration technique.

On accept voluntiers des contributions ne dépassant pas 20 pages dactilographiées. Elles doivent ètre écrites dans la langue maternelle de l'auteur qui voudra bien préciser son titre ou sa position professionnelle et en les accompagnant d'un résumé de l'étude. Les articles doivent ètre addressés au Director, Tropical Forest Experiment Station, Río Piedras, Puerto Rico.

La revue laisse aux auteurs la responsibilité de leurs articles. La reproduction est permise si l'on présice l'origine.

"The printing of this publication has been approved by the Director of the Bureau of the Budget (August 17, 1950)".

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THIRTEENTH ANNUAL REPORT

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The year 1952 was marked by a more wide-spread application of the findings of research than ever before. For the first time in about 10 years large scale planting on the public forests was recommended. Prior to that period, about 22,000 acres of public forest lands were planted, but large scale planting was then discontinued because of numerous failures and high costs. This period has been marked by observation of past plantings and cautious testing of new species, techniques, and sites. Even now only a very limited number of practices can be recommended safely. A result of these recommendations this year has been the underplanting with West Indian mahogany of more than 2,000 acres of dry forest on the south coast and the underplanting of broadleaf mahogany on 450 acres of secondary rain forest. An additional several thousand acres of similar sites are to be underplanted as soon as funds permit.

Another significant development has been the demand which has appeared for eucalyptus for underground piling. The first 30 feet of 12" trees (14 years old) is worth $4.50 on the stump. This development and other prospects for use of this tree for its cellulose have removed the last reason to hesitate in large scale planting of eucalyptus at elevations between 2,000 and 3.000 feet. Areas of natural secondary forest among existing plantations are to be converted to eucalyptus. The planting of eucalyptus by the taungya system is to be throughly investigated during the coming year. If successful it may lead to considerably increased interest in tree planting on private lands.

REORIENTATION OF THE RESEARCH PROGRAM

A highlight of the year's activities was the visit of Dr. V. L. Harper, Assistant Chief of the Forest Service in charge of forest research, and Dr. H. G. Wilm, in charge of the Division of Forest Influences Investigations, both from Washington. They went throughly over the forest problems of the island and the present program of the Station. They gave much valuable advice for the orientation of future work. There is some prospect that as a result of their visit the program of the Station will be extended formally into the fields of forest utilization and forest influences research.

A study of forest utilization in Puerto Rico was made at the request of the Station by Mr. C. C. Bell, Chief of the Forest Utilization Service of the Forest Products Laboratory. Mr. Bell spent 4 weeks in Puerto Rico studying the forests, their products, and wood conversion and fabricating plants. Mr. Bell's report emphasizes three major forest utilization needs of Puerto Rico: (1) increased use of small, low quality and poor-form material, (2) increased production of timber in sawlog size and of high-value form and species, and (3) acceleration of factory tests and field experiments to add to the little information now available on the properties and uses of Puerto Rico's woods. Mr. Bell recommended a broad program of utilization research in the major fields of industrial investigations, pulp and paper, silvicultural relations, timber physics and wood preservation, to be carried out largely at the Station but with cooperation from the Laboratory.

Increased emphasis on research in the field of forest utilization actually took place with the assignment by the Commonwealth Forest Service of Puerto Rico of a full-time professionally trained forester, Miguel Hernández-Agosto, to the Station to assist in the research program. Mr. Hernández has been provided an allotment for materials

and supplies by that Service. Because his training is in the field of forest utilization and because research in that field is much needed and has not made up an important part of the Station's program in the past, Mr. Hernández has been assigned research within that field. He has taken over all going forest products investigations and has laid out a comprehensive program which will lead to more knowledge concerning the quantity and quality of available forest products in Puerto Rico, new uses for these products, and increased durability during their service life. Mr. Hernández arranged for and prepared a cooperative agreement signed during this year between the Forest Services and the College of Agriculture of the University of Puerto Rico for joint research in timber testing and wood chemistry and products pathology.

ACTIVITIES OF INTERNATIONAL SCOPE

Three international trips were made by members of the Station staff during the year. The Division Chief served as a United States representative on the Preparatory Committee for a conference on timber trade to be held under the auspices of the Caribbean Commission. The Preparatory Committee met in Port of Spain and suggested an agenda, papers, and work to be done by the Secretariat prior to the conference, which is now scheduled for April 1953. The Director spent a week in the Dominican Republic during which time he discussed with the Minister of Agriculture the forest problems of the country and the forestry program in progress.

The Division Chief served as a United States delegate to the Fourth Session of the Latin-American Forestry Commission of FAO at Buenos Aires. On the return trip he spent a week at Sao Paulo, Brazil, seeing the extensive eucalyptus plantings of the Companhia Paulista de Estradas de Ferro. Also seen were the forests of the Essequibo river in British Guiana and those of Grenada, St. Lucía, and Dominica in the British Lesser Antilles. These stopovers yielded a wealth of information concerning eucalyptus, the ecology of rain forest, and exotic tree species worth testing in Puerto Rico.

The Station was visited by 14 foresters from 13 different foreign countries during the past year. In adition, five forestry students received training at the Station. For three of these, who were at the Station for five months, it was possible to lay out a well-balanced program of study involving many phases of forestry. Two of these students are graduate foresters from the University of the Andes, Merida, Venezuela.

Publications of the Caribbean Forester lagged behind schedule during the year, and the October issue is still in press. Seven articles were published this year and these concern Argentina, Brazil, the Virgin Islands, and Puerto Rico. More than half of the pages were dedicated to reports on the research at the Station. The mailing list at the end of the year contained 746 names, mostly foreign to the United States and Puerto Rico.

At the request of the Fourth Session of the Latin American Forestry Commission of FAO the Spanish-English glossary of forestry terminology in preparation at the Station during the past ten years is to be submitted in its present incomplete form to the Latin American Forestry Office of FAO at Río de Janeiro for distribution and comment throughout Latin America and return to the Station for revision. One-hundred and nine new Spanish words were defined during the year, bringing the total to date to 802. This is approximately half of the number of terms defined in English.

LOCAL ACTIVITIES

The staff was primarily responsible for the preparation of a report on the forest land resources of Puerto Rico and recommendations for their development and use. The study involved a determination of

critical watershed areas from topographic maps, a through analysis of existing conservation program, and consideration of practical means of more forestry progress. The report made specific recommendations for more forestry education and technical assistance, acceleration of public acquisition of forest land, more forest research, incentives for private owners commensurate with those for other conservation practices, and through consideration of regulatory legislation for critical areas. The report, almost without modification, has been included as Chapter VI of "A Comprehensive Agricultural Program for Puerto Rico" to be published shortly by the U. S. Department of Agriculture.

Dr. Elbert L. Little Jr., of the Division of Dendrology and Range and Forage Investigations of the Forest Service in Washington spent about 3 months in Puerto Rico at the request of the Station to continue work on the manuscript for two popular descriptive books on the trees of Puerto Rico. On a previous trip Dr. Little had collected adequate herbarium material for one volume describing 250 species. During this year about 475 specimens were mounted in the herbarium and he virtually completed the descriptive text. The major task remaining is the drawing of some of the species.

Cooperation with the Soil Conservation Service in encouraging forest planting within the Virgin Islands was continued during the year. Detailed plans were laid out for an extension program, seed collection, ground preparation, propagation, sowing, and planting during the year. Forest lands in four ownerships were mapped and specific recommendations were prepared for the landowners. In addition, a possible 4-H Club tree project was outlined, including activities for seven different months during the year. Three small growth plots were established in natural stands of West Indian mahogany. This program is moving forward slowly in spite of the interest of the Governor. A program of tree planting proposed by the Virgin Islands Corporation in cooperation with the Soil Conservation Service and the Station for next year may produce more results.

An outstanding research event was the Cambalache field day, held on May 22 in the Cambalache Experimental Forest. About 120 persons participated, including representatives of the following agencies dealing directly with landowners: the Soil Conservation Service, the Agricultural Extension Service, Production & Marketing Administration, the Puerto Rico Department of Agriculture and Commerce, Soil Conservation District Boards, the Puerto Rico Land Authority, the Farmers Home Administration, and the Commonwealth and Federal Forest Services. Some 30 boys in the upper grades of a nearby vocational school were also present, as were ten leading farmers from the region. By demonstration and explanations the forest problems of the north coast of Puerto Rico were presented to the group by representatives of the Extension Service, the Soil Conservation Service, and the two Forest Services. Numerous plantations of different species, some clearly successful and some still experimental, were shown to the group, as was demonstration improvement cutting.

Other educational activities during the year included addresses on forest conservation and research to the Farm Forestry students at the College of Agriculture, to the Naval Dependent's School, to about 100 leaders at the Boy Scouts Camp, and to the Garden Club. The staff organized and led a one-week training course for about 25 field personnel of the two Forest Services. Part of the course concerned purely administrative matters, but the biological basis for forestry, the need for research, experiments in progress, and the results found to date which are of importance to them were all presented in detail. Five major field experiments were shown to the group.

Mr. Marrero continued to put the results of research directly to use in laying out and guiding the regeneration program in the Caribbean National Forest. This has involved

the survey and designation of areas of highest priority for planting, plantation care, and stand improvement; the recommendation of techniques; inspection; and the preparation of an annual report. During this year 2,040 acres were treated, including the planting of 810 acres and the care of 1,230 acres of plantations. Similar but less detailed assistance has been given to the larger program of the Commonwealth Forest Service. In adition the staff has served on a committee working toward improved tree distribution to farmers. Recommendations involve direct aplication of research findings and concern propagation techniques, species to propagate, and the sites to which they are adapted.

New publications received in the library during the year total 763. Indexing of an accumulation of past library accessions has been completed. The library now contains about 6,850 titles on tropical forestry or closely allied fields. A much larger general agricultural library is also available to the staff at the University Agricultural Experiment Station, located within 500 feet of the Station headquarters.

The staff of the Station is small, and progress has depended heavily upon assistance from numerous cooperators. Important cooperation received during the year from outside Puerto Rico includes guidance from the two research chiefs from Washington, the forest utilization study by the Forest Products Laboratory, and the progress made on the manuscript. "Trees of Puerto Rico" by a member of the Washington Office of the Forest Service. The British Caribbean Territories made a direct financial contribution for the Caribbean Forester. Another important result of outside cooperation has been the receipt of seed of new tree species from many parts of the world. In exchange for instruction, the foreign forestry students have been of material assistance in carrying out field work.

Within Puerto Rico the establishment, protection, and maintenance of experimental installations, provision of suitable sites, and the use of field stations is contributed by the Caribbean National Forest and the Commonwealth Forest Service. The Commonwealth Forest Service also propagates most of the trees used in regeneration experiments. The assignment of Mr. Hernández to the Station, already mentioned, is another major cooperative benefit from this Agency. The University of Puerto Rico has been an important cooperator, making available its library facilities and through its Agricultural Experiment Station has provided the Station the Río Piedras Woodlot and has assisted directly in the experimental work, particularly in the fields of entomology and experimental design. The Agricultural Extension Service has provided photographic service which at times required the use of their photographer in the field for a day or more. In addition, this Service has arranged for the publication of press releases and the broadcasting of radio talks by the staff. Jointly, the Extension Service, Soil Conservation Service and the Soil Conservation District Board of Supervisors made possible the Cambalache Field Day, by bringing together key people, raising funds, arranging the meal, and presenting some of the information to the group. Re-examination of the Mona Island plantations was made possible by transportation and lodging furnished by the U. S. Coast Guard.

RESEARCH RESULTS

The experimental work of the Station has been conducted on different forest areas throughout the Island of Puerto Rico. Most of the studies are made within public forest lands, either those of the Federal Government or of the Commonwealth. (Fig. 1). Not all of the findings made during the year are considered sufficiently important to warrant description here. Some studies reported a year ago have not progressed sufficiently to warrant another report. For others, not recently reported, progress during the past two or three years is described.

Fig. 1.—Public forest areas of Puerto Rico mentioned in this report. (Areas forestales públicas mencionadas en este informe).

Fig. 2.—Principal areas of forest land in Puerto Rico. (Areas de terrenos forestales en Puerto Rico).

The experimental forests have continued to be centers for much of the silvicultural research. The Cambalache and St. Just Forests are also of considerable value to the local community as a source of wood products. At Cambalache 25 timber sales were made, involving about 2,500 cubic feet of roundwood worth $275. From the same forest 11,018 bundles of fuelwood were taken free of charge by 90 families living nearby. The volume of this fuelwood was about 110 cords. At the St. Just Experimental Area, 1,407 bundles of fuelwood were taken by 20 families. The volume of this material was about 14 cords. From the Río Piedras Woodlot 850 fence posts were made available to the Agricultural Experiment Station of the University in accordance with the plan for management of this forest.

The experiments are here classified in accordance with their major objectives. These include the determination of:

1. The extent and nature of the forests of Puerto Rico.
2. The present and potential contribution of the forests of Puerto Rico.
3. Practical methods of increasing forest land productivity.
4. Practical methods of increasing the utility of wood.

Most of the silvicultural research reported involves studies of tree growth in relation to environment. The only satisfactory method of conducting such studies within natural forests or old plantations has been the establishment of permanent plots in stands representative of the condition desired. Twenty-five of these plots were remeasured during the year and 12 new plots were established.

At the close of the year a critical review of a large number of studies of the site adaptability of different tree species has resulted in the termination of more than 100 of these. Many had already shown most of the information that could be expected from them and others were obviously destined for failure. This represents a material saving in the future re-examination job load and will free staff members for a number of more important new studies.

Mr. Hernández Agosto of the Commonwealth Forest Service prepared the reports presented concerning the studies of forest products and wood utilization which have been under his direction during the last half of the year.

Frequent reference is made to earlier annual reports of the Station. Recent reports were published in The Caribbean Forester as follows: 1949, 11:59-80; 1950, 12:1-17; and 1951, 13:1-21.

Forest Land area approximated

Knowledge as to the area, location, and character of the lands best suited for forests is basic to forest research. Inadequate information of this nature has been available in Puerto Rico in the past. Therefore, in the preparation of a report on forest land resources and recommendations for public forest land acquisition, an attempt was made to locate and ascertain the area of those lands where trees would produce a higher sustained yield in terms of economic and/or social benefits than other crops.

Trees will grow in any part of Puerto Rico, yet on most of the island they are less productive than other crops. Insufficient data are available to make possible a direct comparison of economic returns from forest and nonforest crops. However, one category of land almost unanimously recognized as best for trees: those areas which because of excessive slope (50% or more); heavy rainfall; or shallow, infertile or poorly drained soil cannot be cultivated or pastured continuosly without soil deterioration and/or very low yields, yet which can produce trees as a permanent crop.

All areas exceeding 50% slope were outlined on the topographic maps of the island. By planimetering it was found that the total was approximately 600,000 acres, about one quarter of the land surface of the island. Of this area, about 427,000 acres lie

within blocks of 10,000 acres or more each, which are suitable for efficient forest management. These blocks are located as indicated in Table 1. (See also Fig. 2).

Table 1.—The larger blocks of forests land in Puerto Rico

Location	Area of forest land
	Acres
Northern limestone region	90,000
South slope of the Cordillera	83,000
Sierra de Cayey	60,000
Sierra de Luquillo	47,000
Río Manatí Valley	33,000
Río Arecibo Valley	29,000
Sierra de Atalaya	25,000
Río La Plata Valley	23,000
Guánica	16,000
Tallaboa	11,000
Lajas	10,000
Total	427,000

The remainder of the forest land is in smaller blocks but should provide important local sources of forest products. These data served as a basis for a public forest land acquisition program.

Slow growth in virgin forests confirmed

Studies have been made within Puerto Rico's few remaining virgin forests to determine the nature of these forests and of trees species which compose them, as an indication of what may be expected from different silvicultural treatments. In the past three reports the first data have been presented as to the site requirements, tolerance, and comparative growth rates of different species in the undisturbed forest.

Growth measurements on a large number of trees in the tabonuco and colorado types in the Luquillo Mountains (lower montane rain forest and montane thicket[1]) led a few years ago to the belief that tree diameter growth in virgin rain forest was very slow. The period of measurement at that time was only 2 years and did not provide conclusive evidence to this effect, so a second remeasurement of these was made in 1952, after 5 years.

The results of this remeasurement appear in Table 2. The data for the tabonuco type represent 399 trees of 10 canopy species, tabonuco (*Dacryodes excelsa* Vahl); aguacatillo (*Meliosma herberti* Rolfe); ausubo (*Manilkara duplicata* (Sessé & Moc) Dubard); caracolillo (*Homalium racemosum* Jacq); granadillo *Buchenavia capitata* (Vahl) Eichl); guajón *Beilschmedia pendula* (Sw.) Nees); masa *Tetragastris balsamifera* (Sw.) Kuntze); motillo (*Sloanea berteriana* Choisy); nuez moscada (*Ocotea moschata* (Pavon) Mez.); and roble (*Tabebuia pallida* Miers). Separate analysis showed that in the virgin forest the growth rates of the various species were not sufficiently to warrant separation. More than half of the trees (222) were of the common dominant, tabonuco.

In the colorado type a larger number of trees of each common large species were measured and the data were curved separately. There were 480 trees of caimitillo (*Micropholis chrysophylloides* Pierre); 260 of nemocá (*Ocotea spathulata* Mez.); 832 of caimitillo verde (*Micropholis garcinofolia* Pierre); 828 of camasey jusillo (*Calycogonium squamulosum* Cogn.); 171 of laurel sabino (*Magnolia splendens* Urban); and 171 of palo colorado (*Cyrilla racemiflora* L).

The data on growth rates were curved over tree diameter, and then the age of trees of different diameters were estimated by summing periods required to pass from one diameter class to the next.

1 As classified by Beard. Climax vegetation in Tropical America. Ecology: 25(2):127-158.

Table 2.—**Estimated age of trees in virgin stands, Luquillo Forest**

Diameter at breast height	Estimated Age						
	Tabonuco Type	Colorado type					
	Canopy species	Caimitillo	Nemocá	Caimitillo verde	Camasey jusillo	Laurel sabino	Palo colorado
Inches	Years	Years	Years	Years	Years	Years	Years
4	80	90	200	170	80	100	80
8	[illegible]	160	400	260	200	180	170
12	180	230	570	320	240	250	280
16	[illegible]	290	700	370	440	340	420
20	260			430		430	580
24	300					540	730
36	420						1200

The slow diameter growth of the more important trees in these virgin forests is shown in another way in Table 3, which is based on the analysis of 2,488 trees of species which grow to large size. The data presented are for trees between 2 and 20 inches in diameter and are based upon 5 years of measured growth. Table 3 shows dominant trees to be growing slower than the codominants in the tabonuco type, apparently a consequence of their greater age.

Table 3.—**Diameter growth in virgin stands, Luquillo Forest**

Crown class	Tabonuco type		Colorado type	
	No. trees	Avg. annual Diam. growth	No. trees	Avg. annual Diam. growth
		Inches		Inches
Dominant	27	0.10	123	0.05
Codominant	64	0.13	212	0.05
Intermediate	204	0.13	567	0.04
Suppressed	339	0.05	952	0.03
All trees	634	0.09	1854	0 04

The average annual gross increment (without subtracting mortality) of two 1-acre plots in virgin tabonuco type forest was 60 cubic feet per acre and for eight 1-acre plots in the colorado type was 28 cubic feet per acre.

The slow growth shown in these virgin forests indicates the magnitude of the task required of the forester in making these areas highly productive. Not only must trees which are inferior as to species and form be removed but the growth rate must be augmented many times to make forestry pay.

Relative growth rates of different Luquillo species determined

Puerto Rico's existing forests can generally be improved materially purely by partial cuttings which leave the best trees already present. While the introduction of new superior species by underplanting promises to be a more productive approach to forest improvement on some sites, it has not yet proven entirely successful. In the meantime, reliance must be placed upon the best trees now growing in such stands. The appraisal of these species must consider a number of their characteristics, one of the most important of which is growth rate.

During this year an analysis of all past growth records of the major sawtimber and polewood species within the tabonuco and colorado types of the Luquillo Mountains was made to provide a comparison of their relative growth rates. These data, presented in Table 4, are for trees in the codominant and intermediate crown classes (equal weight to each class), those most common in well managed forest. They are for trees from 4 to 20 inches in diameter.

Table 4.—Diameter growth of codominant and intermediate trees, Luquillo Forest

Species	Trees measured	Avg. annual diam. growth
	No.	Inches
Gallina, *Alchorneopsis portoricensis* Urban	15	0.32
Negra lora, *Matayba domingensis* (DC) Radlk.	85	0.28
Mato, *Ormosia krugii* Urban	47	0.27
Granadillo, *Buchenavia capitata* (Vahl.) Eichl.	15	0.26
Roble, *Tabebuia pallida* Miers	36	0.25
Guama, *Inga laurina* (Sw.) Willd.	14	0.23
Ausubo, *Manilkara bidentata* (A.DC.) Chev.	40	0.20
Achiotillo, *Alchornea latifolia* Sw.	21	0.20
Masa, *Tetragastris balsamifera* (Sw.) Urban	14	0.20
Hueso blanco, *Linociera domingensis* (Lam.) Knobl.	12	0.20
Motillo, *Sloanea berteriana* Choisy	30	0.19
Tabonuco, *Dacryodes excelsa* Vahl.	179	0.14
Yagrumo macho, *Didymopanax morototoni* (Aubl.) Dcne.	54	0.14
Nuez moscada, *Ocotea moschata* (Pavón) Mez.	17	0.10
Roble de sierra *Tabebuia rigida* Urban	60	0.07
Caimitillo, *Micropholis chrysophylloides* Pierre	144	0.06
Laureal sabino, *Magnolia splendens* Urban	46	0.06
Caimitillo verde, *Micropholis garciniifolia* Pierre	514	0.05
Jusillo, *Calycogonium squamulosum* Cogn	292	0.04
Nemocá, *Ocotea spathulata* Mez.	72	0.04

Within each species the growth rate of different trees varied considerably, as did the character of the various stands sampled. Included, however, were a number of managed, well thinned areas. The trees in the lower third of this list grew so slowly that they must be considered of low productivity regardless of the value of their wood. Among these are all of the most common species of the colorado type. It is therefore seen that any considerable increase in the productivity of this area will require a major change in composition, probably involving artificial regeneration with exotic species.

Sierra palm growth related to diameter and height

Sierra palm (*Euterpe globosa* Gaertn) is common in forests above 2,000 feet elevation. Over extensive areas (5,000 acres in the Luquillo Forest alone) it occurs as nearly pure stands. Its value is only protective, and its replacement by other equally protective but more useful trees is desirable. Initially the plan was assumed to be an aggressive rapid-growing species which invaded openings caused by hurricanes. A series of studies of palm growth described in past annual reports have shown this to be untrue; its growth is everywhere slow, ranging from 4 to 10 inches in height per year.

The paucity of trees of other species in mixture with the palms has created some doubt as to whether they will grow well on palm sites. These sites are usually areas of unstable soil, such as rocky slides or river banks. It appears that other trees generally fall over before reaching maturity, for lack of anchorage. Studies of palm growth and of methods to estimate it by the condition of the palms or their environment have been carried out because relative palm growth rates may indicate where within the palm forest the introduction of other better species is most promising. Studies reported a year ago showed the more rapid growth of intermediate and suppressed palms as compared with dominants and codominants, apparently partly a matter of age. Also, a method wa

described for estimating the age of palms from the vertical distance between adjacent leaf scars on the trunk.

During this year an analysis of 5 years of growth of 357 palms in the Luquillo Forest provided further information about this species. The relationship between diameter at breast height and average height growth is seen in Table 5 which is based on curved 5-year growth data. The change in growth rate with diameter is most pronounced below the 6-inch point. It should be understood in interpreting this table that the relationship between diameter and age tends to be inverse. The young vigorous palms are usually larger in diameter than the older trees. It can be concluded from this study that the larger the average diameter, other things being equal, the better the site for palms (and possibly also for other trees).

Table 5.—**Sierra palm growth related to diameter**

Diameter at breast height	Average annual height growth
Inches	Inches
3	1.1
4	2.7
5	4.5
6	5.9
7	6.7
8	7.3
9	7.8
10	8.1

The relationship between initial tree height and average annual height growth during the succeeding 5 years is shown in Table 6. These data show a generally inverse relationship between height and height growth. This further bears out the fact that the younger trees are the most rapid growing.

Table 6.—**Sierra palm growth related to height**

Inicial height	Avg. annual hgt. growth
Feet	Inches
5	6.4
10	7.1
20	7.1
30	6.1
40	4.6
50	3.0

The Present and Potential Contribution of the Forests

Casuarina reaches 16-inch diameter in 20 years on coastal sands

Casuarina (*C. equisetifolia* Forst), a native of Australia, has for many years been Puerto Rico's most popular tree for farm plantings. It is adapted to poor soils, it grows rapidly, its straight trunk is suited for many uses on the farm, and it is attractive in appearance. The species does not produce a workable wood, nor does it, on most sites, grow large enough in diameter for lumber.

One of the first plantations of this species in Puerto Rico was established in 1922 by Central Fajardo at Hacienda Monserrate near the town of Luquillo. This plantation, about, 4 acres in area, contained 2,700 trees spaced 8 x 8 feet. The site was considered worthless for other purposes. The soil was a white, nearly sterile sand, the water table was high, and because of crabs no other crop would grow on it.

This plantation proved to be exceptionally rapid growing and showed the adaptability of this species to protected coastal sands. By early 1932, after 10 years, the topsoil had taken on a dark brown color and was covered by a carpet of needles. Few crabs remained and open herbaceous vegetation had developed beneath the trees. At that time the stand contained a volume of 2,750 cubic feet per acre, nearly all of which was suitable for

posts and poles. Later that same year a hurricane uprooted or broke off all but 25 trees.

A second plantation was established on the same site in 1933. At the end of the tenth year a measurement of 559 trees showed a diameter range from 4 to 18 inches, with a mean of 9.5 inches. The canopy was 85 feet tall and one tree was 105 feet. In the 17th year the number of trees had declined to 206 through gradual thinnings of the weaker trees. The average diameter of those remaining was 14.4 inches.

The 20-year remeasurement of this plantation was made this year. It was found that although the stand is now quite open, many of the trees are declined in vigor. More trees has been cut, so only 171 now remain. These, which undoubtedly are the earlier dominant and codominant trees, now range from 8 to 25 inches in diameter and average 16.2 inches.

The full value of this rapid growth of casuarina has not generally been utilized in Puerto Rico. Although the wood is not high quality for lumber, experiments have shown that it can be successfully treated with preservative which will prolong its useful life to at least 10 years as a post or pole in the ground. Untreated fence posts do not last 24 months, and larger poles generally do not last more than 5 years.

Casucrina plantations on Mona Island deteriorate

During 1937 to 1939 about 400 acres were planted to trees on the coastal plain of Mona Island, midway between Puerto Rico and Hispaniola. This area received about 40 inches of precipitation annually and the soils planted are chiefly beach sands from 6 to 30 inches in depth. The main species planted were casuarina (*C. equisetifolia* Forst) and West Indian mahagony (*Swietenia mahagoni* Jacq.). Although this area is no longer a public forest reserve, the island is almost uninhabited and the plantations have not been disturbed. Because they indicate what might be expected of planting on similar unplanted sites on Puerto Rico, their development has been followed by periodic reexamination and measurement.

Casuarina has proved to be the outstanding species. Possibly because of the drier climate it has not grown as rapidly as at Hacienda Monserrate (described elsewhere in this report) but the trees generally have good form and have produced closed stands. Their diameter after 15 years range from 4 to 12 inches and heights from 30 to 100 feet.

The development of this tree is closely related to the degree of protection from the wind and the quality of the soil. In a protected cove with relatively deep soil the trees average 7.5 inches in diameter and from 80 to 100 feet in height. On a nearby exposed sandy point the trees are only about half as large, the canopy is more open, the foliage is thin and some have dead tops which are being replaced by epicormic branches on the lower trunks. The unhealthy appearance of these trees has developed only recently. There seems to be little prospect for additional growth. The cause appears to be largely the combined effect of exposure to the wind and the almost sterile sandy soil with brackish water beneath.

Although the trees in these plantation are gradually deteriorating, they will probably continue to provide attractive shade along the beach for many more years. However, greater economic return might result from coverting the more exposed areas to a coconut plantation, using the casuarinas as a protective nurse crop for the young palms.

The mahogany has also failed on the more exposed sands but is growing well where protected. In the better areas 15-year-old dominant trees range from 5 to 7 inches in diameter and to 40 feet in height. Where planted closely their form is good. Natural regeneration is abundant in protected areas.

Increasing Forests Land Productivity

Studies in cutover forest guide management

Studies of virgin forest have produced valuable results in that they have shown

silvical relationships in the relatively stable climax environment. Similar studies in forest which has been improved by the reduction in stand density with the removal of overmature and inferior trees show more directly the best silvicultural practices. Significant results of this character were yielded in four half acre plots in the tabonuco and colorado forest types of the Luquillo Mountains, remeasured during the past year, 5 years after establishment.

These plots were improved by a partial cutting in 1947. The residual stands at that time are described in Table 7. Nearly all of the stands above 20 inches in diameter was removed, and the basal area was reduced to about 50 percent of that common in virgin forest. The cutting either removed or liberated at least half of the trees which formerly had been suppressed, leaving a much smaller number of trees in this non-productive class.

The 5-year growth in these plots is shown in Table 8. A sharp contrast in the results in the two types is quite evident. Whereas diameter growth in the tabonuco type accelerated 50 percent, there has been no change in the colorado type. A total of 204 trees in that type, more than half of those in the plots, made no measurable diameter growth during the 5 years. Even the dominant, codominant, and intermediate trees are not growing rapidly. Trees of the most rapid growing species (roble de sierra, *Tabebuia rigida* Urban) in these classes were growing only at the rate of 7 inches in diameter per century. This result confirms that shown in Table 4. It is possible that this is partly due to the great age of many of these trees, as shown in Table 2.

Table 7.—**Residual stand per acre in improved plots. Luquillo Forest, 1947**

Index	Colorado type		Tabonuco type	
	Plot 1	Plot 2	Plot 1	Plot 2
Number of trees by diameter classes				
2 - 6"	726	938	746	682
7 - 12"	58	42	60	68
13 - 20"	20	2	12	18
20"+		2	2	
Total	804	984	820	768
Total basal area, sq. feet	91	68	98	100
Percentage of trees suppressed	38	27	24	27
Total volume, cubic feet	1,708	1,186	1,368	1,456

Table 8.—**Growth in improved Luquillo plots, 1947-52**

Index	Tabonuco type		Colorado type	
	Plot 1	Plot 2	Plot 1	Plot 2
5-year ingrowth; new trees per acre.	298	220	—	52
Mean annual diameter growth, all trees, inches	0.13	0.14	0.03	0.05
Mean annual diameter growth of dominant and codominant trees, inches.	0.20	0.26	0.05	0.05
5-year basal area increment per acre, sq. ft.	30	34	—5	5
5-year gross increment per acre, cu. ft.	600	595	98	115
5-year mortality, cu. ft.	85	15	68	60
Five-year net increment, cu. ft.	515	580	30	55

Continued management, gradually elminating the old trees, might eventually create a more productive stand. However, during the past 5 years there has been almost no crown development, and mortality has continued high, so that a second cutting, if made soon, would excessively open the stand. Moreover, there is almost no young sapling growth so the replacement of the old stand with a young one will apparently be a very slow process. A more promising solution seems to lie in the introduction of other species.

In the tabonuco type the cutting produced a noticeable flush in the undergrowth. (See Fig. 3). The stand density increased rapidly toward its initial basal area. Crown development was also rapid, and closed the canopy. Therefore, in 1952 a second cutting was made in Plot 1 reducing the number of trees per acre from 1,072 to 848 and the basal area from 120 to 105 square feet per acre. In Plot 2 the number of trees was reduced from 1,178to 978 per acre and the basal area from 102 to 89 square feet per acre.

There is some indication that the somewhat heavier cut made in Plot2 5 years ago was more desirable than that in Plot1. Diameter growth, and net increment were higher in this plot. Conclusive evidence will require a separate investigation. It was shown, nevertheless, that the heavier cutting in Plot 2 did not cause serious invasion by vines.

Broadleaf mahogany reacts well to direct seeding, underplanting, and thinning

The successful establishment of West Indian mahogany (*Swietenia mahagoni* Jacq.) by direct seeding on the limestone hills of the Cambalache Experimental Forest (sea level, precipitation 55 inches annually) and the good growth of broadleaf mahogany (*Swietenia macrophylla* King) on this same site led to tests of direct seeding with the latter, more rapid growing species. The advantage of this practices with West Indian mahogany, as compared with planting, were that potted stock (the only alternative) was made unnecessary and that therefore the planting was much cheaper. Direct seeding also was easier because deep pockets of soil did not have to be located for sowing, as was necessary for planting the potted trees. The early growth of seedlings in the forest has been rapid. This practice has been successsful only under partial shade, however, and has failed because of drought on the south coast (sea level, precipitation 30 inches annually).

A sowing was made in late 1950 in the Cambalache Forest, with four seeds per spot under a thinned canopy about 20 feet high. This proved to be a failure because of poor germination. A resowing was made in 1951 and has produced nearly a complete catch. At the end of 1952, after the seedlings had passed through one dry season, nearly all of the spots contain living seedlings which range from 12 to 18 inches tall. The development of a few remaining trees from the earlier sowing shows that these are capable of rapid height growth if provided continuous overhead light.

In the humid mountains the planting of broadleaf mahogany nursery stock appears to be more satisfactory than direct seeding (although the latter has not been tested) because vigorous nursery stock makes much more rapid early growth and is thus better able to compete with the dense native vegetation under those conditions. As on the coast, underplanting is proving to be a safer practice than field planting with this species.

About 40 acres of secondary rain forest were underplanted with broadleaf mahogany in late 1950 in the Luquillo Forest (elevation, 1,000 feet; precipitation, 120 inches annually). The canopy was thinned to provide only about half shade and the trees were spaced 15 to 20 feet apart beneath openings. Because of excessively wet weather survival was only about 60 percent, and a replanting was made. After 18 months the trees averaged 5 feet in height and were very vigorous. There was no sign of damage by the shoot borer

Fig. 3.—Young forest of the Tabonuco Type 2 years after improvement cutting showing the dense flush of under growth. (Rodal joven del Tipo Tabonuco 2 años después de una corta parcial mostrando un marcado vigor en el sotobosque).

Fig. 4.—Recently thinned 13-year-old plantation of broadleaf mahogany (Swietenia macrophylla King) at Río Abajo showing the density of the stand left. (Plantación de caoba hondureña de 13 años de edad recientemente aclarada en Río Abajo mostrando la densidad del rodal remanente).

(*Hypsipyla grandella*). It was clear, however, that all plantation care may not be avoided merely by planting under a canopy. The need for cutting grass and herbs is virtually eliminated, but vines must be removed at least once or twice, and the maintenance of an open canopy above the trees calls for attention probably every 24 months for the first few years. The result of this test and evidence from older field plantings nearby has served as basis for the underplanting of about 800 acres of secondary rain forest on the more protected sites of the Luquillo Forest during the year.

Evidence of the potentialities of broadleaf mahogany in the rain forest zone, has come largely from a small 1931 planting. This plantation, about 4 acres in area, has been allowed to develop without silvicultural attention. After 20 years the basal area was 140 square feet per acre, and the stand was so dense and uniform that 85 percent of the trees were in the intermediate crown class. The crowns are opaque and a deeper green color than is usual in younger plantations. Diameters range from 4 to 15 inches, the average being 9.6 inches. The mean annual basal area increment per tree for the first 17 years was 0.0238 square feet; for the last 3 years it was 0.0342 square feet, indicating continued rapid growth. Many of the trees were forked, but a thinning made this year has eliminated almost all of these. This 20-year thinning yielded nearly 1,000 board feet of sawtimber per acre and has paid the cost of the planting (without interest). The health, size and growth rate of these trees shows this species to be the most promising prospect for similar protected sites within the rain forest zone.

A study of more timely thinnings in the Río Abajo Forest (elevation, 500 feet; precipitation, 80 inches annually) is serving as a guide for practice on more than 500 acres of young plantations of this species throughout the island. In 1950 tests were made in a 13-year-old plantation in a protected limestone sinkhole. This plantation had attained an average diameter (210 dominant and codominant trees) of 6.2 inches, a canopy height of about 50 feet, and a basal area ranging from 80 to 110 square feet per acre. Mean annual basal area growth per tree for the first 13 years was 0.0161 square foot. Current annual basal area growth per tree for the past 2 years in unthinned stands was 0.0151 square foot, only a slight decrease.

Two quarter-acre plots in this stand were thinned in 1950, removing about 320 trees per acre and leaving about 400. The residual basal area ranged from 56 to 76 square feet per acre. The thinning eliminated trees of poor form regardless of size, nearly all of the suppressed trees, and more than half of the intermediates. The opening increased from ⅓ to ⅔ the proportion of all trees in the dominant and codominant crown classes, and even those trees previously in these classes were given more growing space. (See Fig. 4).

Re-examination of these thinned plots this year showed some of the early results. The opening was not sufficient to give rise to a vine problem, although the few vines in the more open areas indicate that this would have been a result of heavier thinning. Almost no trees were bent over by the wind following release. Sprout growth from the stumps of trees cut 2 years ago is unimportant. The diameter growth has been accelerated by the thinning. The average annual diameter growth per tree in these classes for the 2 years since thinning was 0.48 inch (basis, 42 trees), as compared with 0.44 inch (basis, 42 trees) in adjacent unthinned plots. The difference is more marked if all of the remaining trees (including the subordinates) are included in this comparison: 0.26 inch vs. 0.17 inch. A most significant result is the increased dominance of the larger trees. They are making very rapid height growth and at least 50 trees per acre stand out well above the general canopy level. These are undoubtedly final crop trees. Another thinning will not be needed for growth acceleration until the crowns of these large trees grow together, at least 5 years and possibly 10 years

after the 1950 thinning. At the end of 5 years, however, it may be desirable to thin from below, harvesting merchantable material available in declining subordinate trees.

Twenty-year mangrove responds quickly to thinning and seed cutting

Tidal forest dominated by white mangrove (*Laguncularia racemosa* (L.) Gaertn.) covers an area of more than 15,000 acres on the banks of estuaries, lagoons, and protected bays of Puerto Rico. Because of its accessibility this forest has been heavily used since early times. The large trees are now gone but regrowth is rapid so these areas are still largely covered with young forest. Invasion by most other species is precluded by the adverse soil, and white mangrove is nearly pure over most of the area. (See Fig. 5).

In spite of what appear to be favorable conditions, the growth of mangrove is not generally satisfactory. Clear cutting, the usual practice, has resulted in dense sapling stands which stagnate. Studies have shown that as many as 19,000 stems per acre may devolop to a diameter of half an inch or more. Then, as no trees quickly outgrow their neighbors and become dominant, growth must await the slow elimination of thousands of trees, often accomplished by boring insects. A study of 223 1-inch trees in this stage showed their average diameter growth to be only 0.6 inch over a period of 11 years. Since the trees are too small for must uses and their thinning is expensive, this stagnation is an important obstacle to high productivity of this type of forest.

Two methods which may reduce the density of these young stands are being tested. The first consists of partial cuttings, with the objective of creating an all-aged forest. The major problem which must be faced are the apparent intolerance of the species and the danger of windthrow. The second method is clear cutting in narrow strips perpendicular to the prevailing winds. Here the plan is to gradually progress windward, cutting a new strip as soon as the existing one is satisfactorily regenerated. The dangers here are windthrow and the prospect that a strip sufficiently wide to assure regeneration may also produce an overdense young stand.

The stand selected for these tests, located within the Aguirre Forest, developed after clearcutting in 1930. The average diameter of the dominant and codominant trees is 8 inches and the basal area ranges from 110 to 140 square feet per acre. The canopy is at about 60 feet. Four quarter-acre plots were established in 1949 to determine the growth rate within the stand prior to any change. It was found during the past 3 years diameter growth averaged only 0.11 inch per year (0.20 inch for dominant and codominant trees alone), that an average of 95 trees died per acre per year; and that there was no net change in basal area or volume.

In two of the plots (excluded from the above analysis) a windstorm in 1950 blew over 82 trees, creating openings in the canopy. Adjacent trees were remeasured and reclassified as to crown position after the storm. An analysis of the growth of 104 of these trees appears in Table 9. The growth comparison is based on the periods 1949-50 (before the storm) and 1950-52 (after the storm). The last two lines in Table 9 indicate that marked immediate growth acceleration of subordinate trees is possible in this stand as a result of release, even among those trees which have probably been dominated for 20 years.

Table 9.—**Effect of release or mangrove growth**

Grown class		Number of trees	Avg. annual diameter growth	
Before release	After release		Before release	After release
			Inches	Inches
Codominant	Dominant	9	0.23	0.27
Intermediate	Codominant	38	0.18	017
Intermediate	Dominant	4	0.04	0.40
Suppressed	Intermediate	53	0.06	0.17

The windstorm provided valuable information concerning silviculture. As has just been shown, the stand will react to release. It was also found that it was generally the largest trees which blew over. Thus a thinning, which is desirable to increase increment, should harvest these large trees. Accordingly, two of the plots were thinned with this in mind, removing 208 trees per acre from one plot and reducing the basal area from 129 to 78 square feet per acre. In the other plot 328 trees were removed per acre, and the basal area was reduced from 108 to 63 square feet per acre. These plots will be observed to determine future growth, windthrow, and regeneration.

The strip cutting was started in 1951 in the same stand. A strip 66 feet wide by 660 feet in length was cut through the forest from north to south. The wood was converted into charcoal. Examination at the end of one year showed no wind damage along the edges of the strip. The number of stumps which had sprouted was insufficient to make a stand. Moreover, their stems are crooked and will not produce good trees. A fair crop of new seedlings about 4 inches tall appeared in the eastern half of the strip. Most of these are beneath overhanging branches of trees on the east side of the strip. Elsewhere within the strip are a few lines of seedlings located at what was evidently the high water line when they matured. To the windward of the strip, to about 30 feet into the forest, the soil is covered with a dense stand of seedlings, apparently sufficiently tolerant to withstand overhead shade with side light. Further observations will be necessary to determine whether the strip is the proper width and when a second adjacent strip can be cut on the windward side.

Eucalypus experience summarized

Eucalyptus, because of rapid growth in South America and elsewhere, attracted attention years ago and many species were introduced into Puerto Rico. By 1940, a few trees were growing on farm throughout the island and there were a few small plantings in the public forests. Since then more than 2,000 acres have been planted with *E. robusta* and *E. kirtoniana* on the public forests. Seed of additional species has been introduced from Brazil and Guatemala and planted experimentally on different sites. The progress of these plantings has been described periodically in past annual reports. Experience to date with the outstanding species is briefly summarized here.

E. triantha Link. — Planted on a variety of sites from sea level to 3,500 feet elevation. Not promising. Has failed on laterite soils and growth has been erratic elsewhere. On one of the best sites with a deep loose red soil in the Luquillo Forest (elevation, 500 feet; precipitation, 120 inches) individual 8-year-old trees have attained a diameter of 7 inches and a height of from 40 to 60 feet. Nevertheless, most of the trees are much smaller, poorly formed, and weak.

E. alba Reinwardt.—Planted on a variety

Fig. 5.—Typical young mangrove stand in the San Juan forest. This stand, prior to thinning, had become so dense that diameter growth was negligible. (Rodal típico de mangle en el bosque de San Juan. Este rodal, antes del aclareo, era tan denso que el crecimiento diametral fué lento).

Fig. 6.—

Fifteen-year-old plantation of Eucalyptus robusta Smith in the Toro Negro Forest showing the good form of the trees, and also the open character of the stand. (Plantación de Eucalyptus robusta de 15 años de edad en el Bosque Toro Negro mostrando la buena forma de los árboles y la naturaleza abierta del rodal).

of sites from sea level to 3,500 feet elevation. The best adapted species yet found for elevation from sea level to 500 feet. On a shallow soil in the St. Just Experimental Area (elevation, 300 feet; precipitation, 70 inches annually) an 8-year-old plantation is 40 to 60 feet tall, with trees 3 to 5 inches in diameter. On a deep loose red soil in the Luquillo Forest (elevation, 500 feet; precipitation, 120 inches annually) 8-year-old trees are 6 to 9 inches in diameter and 60 to 75 feet tall. On a poor heavy soil in the Toro Negro Forest (elevation, 3,500 feet; precipitation, 110 inches annually) 7-year-old trees average 13 feet in height, with a maximum of 25 feet. Excessive taper and flat-topped crowns indicate that this species is not as well adapted to this higher site as some other species. On a very poor laterite soil in the Maricao Forest (elevation, 2,000 feet; precipitation 100 inches annually) this species failed to grow.

E. botryoides Smith. — Planted on a variety of sites from sea level to 3,500 feet elevation. Only fair on the best sites tested, elsewhere a failure. In the Luquillo Forest (elevation, 500 feet; precipitation, 120 inches annually) 8-year-old trees are 60 feet tall on a deep loose soil. The stand is not uniform, however, and many trees are stunted.

E. citriodora Hook. — Planted on a variety of sites from sea level to 3,500 feet elevation. Generally slow-growing and thin-crowned irrespective of site. On a deep soil in the Luquillo Forest (elevation, 500 feet; precipitation 120 inches annually) gummosis is common and most of the trees have died during the first 8 years. In the Toro Negro Forest (elevation, 3,500 feet; precipitation, 110 inches annually) on a heavy degraded soil 7-year-old trees average only 10 to 12 feet in height.

E. gummifera (Gaertn) Hookr. — Planted only in the mountains. Survival good, trees thrifty and growth slow. At Toro Negro (elevation, 3,500 feet; precipitation, 110 inches annually) 6-year-old trees average from 15 to 20 feet in height.

E. globulus Labill. — Planted only in the mountains. Unadapted. A planting in the Toro Negro Forest (elevation, 3,800 feet; precipitation, 120 inches annually) is not growing well. After 8 years a few trees are 25 feet tall, but the average is not more than 12 feet. Experience elsewhere indicates that this species requires a cooler climate.

E. kirtoniana F. v. M. — Planted on a variety of sites, mostly above 2,000 feet elevation. This species, previously reported as *E. resinifera* Smith, was identified during the past year. It is as well adapted to Puerto Rico as any other species, and its height growth is possible better than all others. Trees planted in the Toro Negro Forest (elevation, 3,000 feet; precipitation, 110 inches annually) in 13 years have grown to diameters from 6 to 13 inches and to heights from 75 to 90 feet. This is on a deep loose soil of fair to low productivity. Codominant trees in this plantation are growing at the rate of more than 1 inch in diameter annually. Form excellent.

E. maculata Hook. — So far has been planted in four locations from 500 to 3,500 ft. elevation. On a deep loose red soil in the Luquillo Forest (elevation, 500 feet; precipitation, 120 inches annually) 8-year-old trees are 35 to 45 feet tall and trees 3 to 5 inches in diameter, one of the best species on this site. On a poor heavy soil in the Toro Negro Forest (elevation, 3,500 feet; precipitation, 110 inches annually) 7-year-old trees average 22 feet, with a maximum of 25 feet, are thrifty and very uniform and one of the best in this poor soil. On a very poor laterite soil in the Maricao Forest (elevation, 2,000 feet; precipitation, 100 inches annually) 5 year old trees average 6 feet with a maximum of 12 feet. *E. maculata* is one of the best adapted species particularly at the higher elevation. It does not show gummosis and early death anywhere to the same extent than *E. citriodora* in the sites where both have been planted.

E. pilularis Smith.— Planted only in the mountains. Growth only fair. In the Toro

Negro Forest (elevation, 3,500 feet; precipitation, 110 inches annually) survival was high and the trees are healthy and well formed, and average height is 25 feet after 8 years.

E. propinqua Deane & Maiden.—Planted on a variety of sites from sea level to 3,500 feet elevation. Requires better soils than where tested. In the Luquillo Forest elevation, 500 feet; precipitation, 120 inches annually) only a few trees developed well, in the lower better areas of the plantation. Here the maximum size is 7 inches in diameter and 60 feet in height after 8 years. In the Toro Negro Forest (elevation, 3,500 feet; precipitation, 10 inches annually) a few trees along the valley bottom attained 25 feet in height after 7 years.

E. resinifera Smith. — Planted on a variety of sites from sea level to 3,500 feet elevation. One of the best adapted species in the mountains. In the Toro Negro Forest (elevation, 3,500 feet; precipitation, 110 inches annually) 7-year-old trees are thrifty, uniform and from 30 to 35 feet in height. In the Maricao Forest (elevation, 2,000 feet; precipitation, 100 inches annually) on a very poor laterite soil where 20 other species of eucalyptus have failed. the trees average 20 feet in height after 8 years. In the Cambalache Experimental Forest (sea level; precipitation, 55 inches annually) the trees have also attained 20 feet in height, and 4 inches in diameter in 8 years. This is better development at sea level than most other species of eucalyptus, but since growth has declined recently it appears that the species is not well adapted here.

E. robusta Smith.— Planted on a variety of sites from sea level to 3,800 feet elevation. The most widely planted species in Puerto Rico. Well adapted to poor soils, particularly those which are wet, and even laterite, above 1,500 feet elevation. Not adapted at sea level. On wet deep soils at elevations from 2,000 to 3,000 feet 13-year-old trees range from 8 to 16 inches in diameter and to 75 feet tall, and there is no sign of a decline in growth. (See Fig. 6).

E. sideroxylon A. Cunn. — Planted only in the mountains. Not outstanding, but thrifty and of good form. In the Toro Negro Forest (elevation, 3,500 feet; precipitation, 110 inches annually) 7-year-old trees average 30 feet in height.

E. umbellata (Gaertn) Domin.—Planted on a variety of sites from sea level to 3,500 feet elevation. Like *E. alba*, and unlike all others tested, this species has grown best at low elevation. In the St. Just Experimental Area (elevation, 300 feet; precipitation, 70 inches annually) on a well-drained shale soil 8-year-old trees are from 3 to 6 inches in diameter and 50 to 60 feet tall. On the other hand, in the Cambalache Experimental Forest (sea level; precipitation, 55 inches annually) trees of the same age on a heavy soil are not thrifty. They average about 3 inches in diameter and form 35 to 50 feet in height and their crowns are thin. In the Río Abajo Forest (elevation, 500 feet; precipitation 80 inches annually) 8-year-old trees average only 8 to 25 feet in height. This is largely due to a very infertile degraded soil. At 3,500 feet elevation they have made almost no growth and are apparently destined to fail.

The recent appearance of a good market for eucalyptus piling and the possibility that it may also be used for wall board make eucalyptus production one of the most promising prospects for thousands of acres of idle private land which is deforested and needs protection. In recognition of this development further investigation will be made of the site adaptability of different species. Additional species are being introduced, and those already growing here will be tested on better sites. Investigations will also be directed toward better utilization of the wood.

Mexican cypress continues rapid growth

Mexican cypress (*Cupressus lusitanica* Mill), a valuable conifer native to Central

America and Mexico, was introduced 4 years ago and has been tested on a variety of sites, mostly at upper elevations. It appears to be one of the most outstanding trees ever introduced.

A 4-year-old plantation in the Luquillo Forest (elevation, 1,800 feet; precipitation, 140 inches annually) on a deep but waterlogged soil has reached a height of 12 feet. In the Toro Negro Forest (elevation, 3,500 feet; precipitation, 120 inches annually) a 2-½-year-old plantation on an exposed slope and a rocky shallow soil is more vigorous than either eucalyptus or roble (*Tabebuia pallida* Miers). The average height of the cypress is 7 feet, with trees to 12 feet. Trees underplanted beneath abandoned coffee shade in the Toro Negro Forest are growing well despite the shade. On a very poor lateritic soil in the Maricao Forest (elevation 2,000 feet; precipitation, 100 inches annually) the trees have begun height growth immediately after planting and exhibit a bright green color not found in any of the other trees tested on this site nor in the native vegetation. At this location even eucalyptus appears destined to failure.

This species appears to be outstanding in many respects. With a minimum of weeding, young trees are able to compete with aggressive vegetation such as tall ferns and molasses grass (*Melinus minutifolia*). It is growing well in an exceptionally wide range of conditions, from near sea level to 3,500 feet elevation and on the poorest soils of the island. It apparently will grow well both under shade and in the open. Its early growth rate exceeds that of most other trees planted.

Only one undesirable characteristic has become apparent so far, and that may prove to be of minor importance as the trees develop. On some sites the trunks grow so fast that they are very flexible and tend to bend over in the wind. This is not everywhere a problem, since little wind damage has taken place at Toro Negro.

Casuarina stands provide good environment for underplanting

Casuarina (*C. equisetifolia* Forst) is planted widely in Puerto Rico to protect soils degraded by cultivation. The tree is adapted almost everywhere in the island below 1,000 feet elevation, and it grows rapidly. However, because ants destroy the seed it does not reproduce itself. Thus if casuarina is to be perpetuated it must be replanted periodically at a considerable cost. If other tree crops are to succeed it. technique of conversion are needed which do not expose the site.

A study of conversion from casuarina to other forest crops was begun recently by underplanting different trees beneath stands of casuarina. It was thought that if these species were established in advance of the cutting that continuous soil protection could be provided. The first underplanting was made in 1949 on a shallow soil in the St. Just Experimental Area (elevation, 300 feet; precipitation, 70 inches annually) beneath a 4-year-old stand of casuarina which provided a continuous canopy. A second underplanting was made in 1950 on a degraded deep red soil under a similar plantation in the Río Abajo Forest (elevation, 500 feet; precipitation, 80 inches annually). In this latter case the casuarina itself was declined due to what appears to be a root rot.

Results at St. Just are encouraging. Six species are very thrifty after 3 years, much more so than would have been expected in the open on this site. These include guaraguao (*Guarea trichilioides* L.) and capá prieto (*Cordia allidora* (R. & P.) Cham), two valuable timber species common in natural forests. The first is known to be tolerant, and has grown slowly, as is typical shortly after planting. The capá prieto, a less tolerant tree, ranges from 4 to 8 feet tall. Another species, capá blanco (*Petitia domingensis* Jacq.), is generally considered very intolerant, ranges from 3 to 7 feet in height

and is only slightly spindly because of the shade. Roble (*Tabebuia pallida* Miers), another intolerant tree, is from 2 to 6 feet tall, growing rapidly and showing no effects of suppression. The common coffee shade, tree guaba (*Inga vera* Willd) average 5 feet in height and is very vigorous. Broadleaf mahogany (*Swietenia macrophylla* King) is the most vigorous tree of all those tried. It ranges from 5 to 8 feet in height, and the new growth is succulent and deep green as if fertilized with nitrogen. (See Fig. 7). Casuarina seedlings underplanted in this experiment are dying apparently for lack of light.

Results to date indicate that the shade of casuarina is insufficient to prevent rapid devolopment of a number of other trees species in the understory. The thrift and good color of the underplanted trees do not bear out the common belief that casuarina, because it grows rapidly on poor sites, exhausts the soil. The good development of the coffee shade tree, guaba, makes desirable further research on the conversion of casuarina stands to coffee plantations. Coffee trees planted beneath casuarina at Río Abajo are also growing well.

Two pre-emergence herbicides prove effective

Weeding in the forest nurseries is one of the largest costs of stock production. The use of selective herbicides has in many places reduced this cost, and a few experiments have been undertaken in Puerto Rico to determine the suitability of herbicides for this purpose here. A year ago it was reported that the application of a mixture of sodium trichloro-acetate (TCA) at the rate of 50 pounds per acre and 2,4-D (amine salt) at the rate of 8 pounds per acre gave weed control in the Toa Nursery for 8 weeks, and that transplanting of seedlings of casuarina or sowing seeds of mahogany could be done safely 2 weeks after treatment.

Pre-sowing treatment as described is both effective and advantageous. However, in the hope that similar control might be possible using herbicides which could be applied after sowing (and thus saving the period of time between pre-sowing treatment and sowing) a number of tests of pre-emergence treatment were made this year. Three herbicides were used: TCA, sodium pentachlorophenate (Santobrite) and "Matona 30-2-2" (a dinitro weed killer in weak solution). TCA was used at the rate of 20, 50 and 100 pounds per acre. Sodium pentachlorophenate was used at 15 and 30 pounds per acre. Matona was applied at the rate of 6 gallons per acre. The species tested was broadleaf mahogany (*Swietenia macrophylla* King). To determine the tolerance of the seedlings the herbicides were applied at one, two, and three weeks after sowing (Mahogany seedlings typically appear above the surface about 3 weeks after sowing).

TCA at 20 pounds per acre was effective as an herbicide, especially against grasses. When applied more than one week after sowing or with applications heavier than 50 pounds per acre it was injurious to the seedlings. The 20-pound application kept the beds sufficiently clean (not more than 35% covered with weeds) for 8 weeks after treatment.

Sodium pentachlorophenate at either rate of application, was both safe and effective when applied one week after sowing. Later applications did not damage the tree seedlings but neither did they control the weeds, which at that time had already germinated. Application of 15 pounds per acre 1 week after sowing kept the beds sufficiently clean for 8 weeks. Matona did not kill weeds at the rate applied.

The best pre-emergence treatments with TCA and sodium pentachlorophenate found this year are superior to the pre-sowing treatments recommended last year because they eliminate the period of waiting between application and sowing. In addition, and for this reason, they are effective to 8 weeks instead of 6 weeks after sowing. Also, with TCA it was found that application of 20 pounds per acre is as effective as 50 pounds (the lightest application last year).

Additional tests with these and other pre-emergence herbicides are warranted. Subsequently post-emergence herbicides will be tested. This type of treatment, which might prove permissible at any time after the seedlings come up, would be much more satisfactory than any of those described here (these do not eliminate the final weeding), but the prospect of finding so selective a material seems remote.

Coffee shade research begins

Recent reports have pointed to the desirability of perpetuating the presently declining coffee industry. The coffee plantations provide a protective cover on nearly 10 percent of the land surface of the island, the steepest and most erodable areas. The cutting of coffee plantations, which has taken place on a large scale during the past 10 years, leads to a brief cycle of cultivated crops which degrades the soil and terminates in idle grasland or brush.

A year ago a survey of coffee yield was conducted jointly with the Bureau of Plant Industry to orient research in this field which might assist coffee farmers. Several important forestry phases deserve investigation. Study of a number of present and potential shade trees was begun this year. BPI has undertaken a formal study of shadeless coffee production.

The common coffee shade tree species in Puerto Rico are guaba (*Inga vera* Willd.) and guamá (*Inga laurina* Sw.). The former is apparently exotic; the latter native. Guaba is generally superior to guamá because of its more spreading form. Both have insect and disease problems which not only materially limit the development and life of the shade trees themselves but also adversely affect the coffee plants. In the belief that some of the many Ingas native to other countries might prove superior for coffee shade, a number of species were introduced from Venezuela by the Puerto Rico Department of Agriculture and Labor in 1929 and 1930.

Most of the early plantings following the introduction are now gone, and there is little record as to their development. The most outstanding species, however, guamá venezolano (*Inga speciosissima* Pittier) has become popular as a coffee shade tree, and each year hundreds of thousands of seedlings are being propagated by the Forest Service and distributed to farmers. A few of the original trees still remaining at Utuado (elevation, 400 feet; precipitation, 80 inches annually) after 23 years are about 10 inches in diameter, 30 feet tall and of spreading form with denser shade than guaba and guamá. This species is easy to propagate, its survival after planting is uniformly high, and it has been free from significant insect attacks and disease. In the coffee region (elevation, 1,500 to 2,000 feet; precipitation, 90 to 100 inches annually) this species makes very fast growth. Three-year-old trees average 2 inches in diameter and 10 to 15 feet in height. Six-year-old trees average 3 to 5 inches in diameter and 15 to 18 feet in height.

Other less well known species introduced at the same time include *I. fastuosa* (Jacq.) Willd., *I. spuria* Humb. & Bonpl. and an unidentified species, probably *I. punctata* Willd. The first two of these species have grown to 50 feet in height in 23 years and are of better form for shade than *I. speciosissima*. Trees of *I. fastuosa* 13 years old on a protected site with deep soil at 1,500 feet elevation (precipitation, 90 inches annually) have grown to 10 inches in diameter and 35 feet in height and are very vigorous.

A collection of small plantings of these different species has been established in the arboretum at La Catalina in the Luquillo Forest to provide seed for additional testing. Seedlings of *I. spuria* Humb. & Bonpl. apparently one of the best of the introductions (yet little used to date) were distributed to five farmer cooperators for testing in the coffee region.

Preliminary tests, described elsewhere in this report, were begun with casuarina as a nurse crop for coffee shade trees. First indications are that casuarina shade is

sufficiently open for rapid development of guaba beneath these trees. A test is also being made of broadleaf mahogany (*Swietenia macrophylla* King) as a coffee shade. The crown of mahogany is so dense that wide spacing or frequent prunings and thinnings will undoubtedly be required. This first test, begun, on the St. Just Experimental Area (elevation, 300 feet; precipitation 70 inches) will be carried out also on a few farms in the coffee region. Future studies will also include eucalyptus as a coffee shade.

Young limestone forest closes rapidly after improvement cutting

The limestone hills of the north coasts of Puerto Rico make up more than 10 percent of the land surface of the island. They are nearly completely covered with secondary forest and have been cut over so frequently that only small trees remain. Although good tree species not native to this site, such as West Indian mahogany, will grow on it, the soil is so shallow that a dense stand of sawtimber probably will never develop. On many sites the improvement of the existing forest by partial cuttings with the objective of maximum post and pole production is the most promising silvicultural practice. Since nearly all of this land is in private ownership this improvement must be cheap and must yield early returns.

A typical young stand on the west slope of a limestone hill in the Cambalache Experimental Forest (sea level; precipitation, 55 inches annually) was selected in 1950 to investigate this problem. The area was opened to about 60 percent shade by eliminating trees unsuited for post or poles because of poor form or inferior wood. Dense clumps of better trees were also thinned where necessary. This cutting yielded, per acre, about a cord of fuelwood and 40 fence posts, and cost about four man days.

The stand left contained 1,160 trees per acre of 2 inches or more in diameter, with an average diameter of 2.4 inches and a basal area of 39 square feet per acre. About 57 percent of the basal area was in good post species. Vines have not formed a problem, and at the end of 1 year another light cutting was made to reopen the canopy. Another similar cutting was made at the end of the second year. These each removed less than half as much volume as the first cutting but provided fuelwood such as would be needed by a farmer. The 235 dominant and codominant trees per acre now average 3.6 inches in diameter and contain good posts. They are growing in diameter at the average rate of 0.21 inch per year. Future cuttings should yield as much or more polewood as fuelwood volume.

Continued study of this area is needed before the economics of this practice are fully known. In the first 2 years only a few saplings have appeared beneath the stand. Host of these are sprouts from stumps left after the first cutting. The amount and quality of the natural reproduction will in a large measure determine the success of this technique.

Bamboo continues rapid growth on better sites

Bamboo appears to have great potentialities in Puerto Rico. Numerous species adapted to the island are elsewhere of value as raw material for a wide variety of articles of commerce. The availability at the Federal Experiment Station of planting stock of a number of useful species not heretofore throughly tested led to experimental plantings on forest lands throughout the island.

The earliest plantings were made on a poor lateritic soil in the Toro Negro Forest (elevation 3,000 feet; precipitation, 110 inches annually) in 1945. Three species, *Bambusa tulda* Roxb; *B. tuldoides* Munro; and *B. longispiculata* Gamble ex Brandis were planted on an area of about 20 acres. After a slow start, the 7-year-old plants now have more than half of their culms ready for harvest. The diameter of these culms

varies considerably with site and should continue to increase with age. *B. tulda* is the largest, with culm diameter from 3/4" to 1-1/2" in the ridges and from 2" to 3" in the valley bottoms. This bamboo is suited for furniture.

On a better site in the Luquillo Forest (elevation, 800 feet; precipitation 120 inches annually) on a deep red soil 4-year-old plants of *B. tulda* and *longispiculata* are up to 30 feet in height in 4 years. At a spacing of 10 x 10 feet they have killed out all competing vegetation.

On a limestone hill in the Camblache Experimental Forest (sea level; precipitation, 55 inches annually) a 5-year-old underplanting ranges from 15 to 30 feet tall. The culms have reached the canopy level and are developing rapidly in spite of a very shallow soil.

On a poorly drained site beneath montane thicket in the Luquillo Forest (elevation, 2,500 feet; precipitation, 180 inches annually) 5-year-old clumps of the four species *B. tuldoides*, *B. tulda*, *B. longispiculata*, and *Dendrocalamus strictus* Nees are stunted and chlorotic. The tallest clumps (*B. tulda*) are only 10 to 15 feet in height and the culms are only about 1 inch in diameter. *Dendrocalamus strictus* is only 6 feet tall and many plants are dying back.

The use of young sprouts as planting material has continued. About 100 rooted sprouts removed from recently planted offsets were planted in the Cambalache Forest. The survival was above 90 percent. Those plants which died were those with least roots and rhizome attached.

Studies proposed for the future include fertilizing in the montane thicket and extending tests in the northern limestone region.

Cedro macho survives planting well

Cedro macho (*Hieronyma clusioides* (Tul.) Griseb), a tree of the limestone region of the north coast, which produces a beautiful dark red furniture wood, has not been widely tested because of the irregularity of seed crops and the difficulty of collecting, drying, and storing the seed. Small-scale tests made years ago in the Río Abajo Forest (elevation, 500 feet; precipitation, 80 inches annually) showed that the tree was only moderate in growth rate but was tolerant and generally of excellent form.

An exceptional seed crop in 1951 and rapid drying of the seed made possible the production of 100,000 seedlings for more extensive testing. Of these, 86,000 were underplanted in the Guilarte Forest (elevation, 3,000 feet; precipitation, 100 inches annually) and in the Río Abajo Forest where this species is native. Underplanting of about 2,000 trees each were made on five other sites, including two in the rain forest, on sites similar to those in the Lesser Antilles where the close relative *H. caribaea* Urb., is a prominent tree. The stock used was 10 to 16 inches tall and bare-rooted, and the weather was good. With the exception of the planting in the Cambalache Experimental Forest survival has everywhere exceeded 80 percent. At Cambalache an unseasonal dry period immediately after planting killed about 50 percent of the trees. Most of the surviving trees showed little sign of shock due to planting and resumed growth shortly thereafter.

Roble dominicano survives planting well

Roble dominicano (*Macrocatalpa longissima* (Jacq.) Britton) is one of the most important trees species in Haiti, growing well on adverse sites and producing a timber suited for construction and general farm uses. It is related to Puerto Rico's roble blanco (*Tabebuia pallida* Miers) but grows to a larger size. In the belief that this might prove a superior species for the reforestation of degraded soils, test plantings of 6,000 trees were made this year on several sites, including the Luquillo Forest (elevation, 800 feet; precipitation 120 inches annually), the Cambalache Experimental Forest (sea level, precipitation, 55 inches annually), the Susua

Forest (elevation, 500 feet; precipitation 50 inches annually) and the Maricao Forest (elevation, 2,000 feet; precipitation, 100 inches anually).

Survival has been more than 90 percent on all sites, indicating that this species stands transplanting exceptionally well. On laterite soil at Susua and Maricao, however, it appears destined to fail. The best development is in the Luquillo Forest, where the trees have reached a height of 4 to 5 feet on the more protected areas. This is taller than most other trees at this age. Although this species appears to be more delicate than the native roble its development will be followed by further examinations.

Mago makes outstanding growth on north coast

Mago (*Hernandia sonora* L.) produces a wood used for interior work in Trinidad and the Lesser Antilles. It is native to Puerto Rico but is relatively uncommon. It has been tested for regenerating degraded farm lands. A small 1944 planting in the St. Just Experimental Area (elevation, 200 feet; precipitation, 70 inches annually) has shown this species well adapted to a loose shallow soil in this environment. In 1952, after 8 years, the average diameter is 3 inches and the average height is 30 feet. The trees are very thrifty and of excellent form. They have shed side branches very satisfactorily. More extensive tests on other sites are warranted.

Mistletoe on maga less virulent than predicted

The report for 1951 described a mistletoe (*Phthirusa* sp.) which has attacked extensive young plantations of maga (*Montezuma speciosissima* (Sessé and Moc.) Dubard) in the Guajataca Forest (elevation, 500 feet; precipitation, 70 inches annually). It was found in 1950 that in one area 80 percent of the trees in a 13-year-old- plantation of this valuable furniture species had become infected from trees of capá prieto *Cordia allidora* (R. & P.) Cham.) in adjacent mixed forest. A plantation in a 14-acre sinkhole was thinned and pruned in 1950 to eliminate all visible mistletoe. A year later mistletoe reappeared on half of the trees, and was so common that it was thought to be largely reincidence. The only practical solution appeared to be conversion of the plantation to a tree species immune to attack, possibly by underplanting.

Re-examination of this area in 1952, a year later, shows the mistletoe to be still common, but apparently not so vigorous as it appeared a year ago. Close study of a number of marked trees has shown that almost no new incidence has appeared in the second year following treatment. This indicates that most of what seemed to be an alarming re-invasion of the parasite a year ago was rather a regrowth of plants not thoroughly removed from the trees. Moreover, because the plantation is growing in height, the older lower limbs (which supported the best developed parasites) are weakening and dying, a process which kills the mistletoe also. Even some of the clumps of mistletoe found a year ago on the trunks are now gone. Although these may be merely dormant, the parasite is apparently inactive. Possibly even more important is the fact that the infected trees have not been deformed and are growing as rapidly as their uninfected neighbors. It may prove that maga can grow satisfactorily despite the mistletoe. Further examinations will be made to determine whether this is true.

Avelluelo develops rapidly in central mountains

Avelluelo (*Colubrina arborescens* (Mill) Sarg.) is a favored polewood native to the coastal plain, chiefly in the limestone section. It was planted early in several forests at low elevation and was rejected because of slow growth. What may be a larger form of this tree was found in the interior of the island and planted in the Guilarte Forest (elevation, 3,000 feet; precipitation, 100 inches annually) in 1944. This plantation has made outstanding growth and the trees are

of excellent color and form. They have outgrown all species planted except eucalyptus. In 4 years they averaged 8 feet in height, and this year, after 8 years they averaged 28 feet in height. They are located on ridges with poor soil, indicating that this is a promising species for the regeneration of degraded sites. Additional plantings are to be made.

Pomarrosa can be controlled by partial cuttings

Pomarrosa (*Eugenia jambos* L.), a naturalized exotic, is an understory tree in secondary forests in much of the humid portion of Puerto Rico. It is bushy in form and although under favorable conditions its growth is very rapid, it generally produces no straight stems and is used primarily for fuel. It produces such a dense shade as to preclude the development of trees of better species beneath it. Whereas in some places it is valuable for reforesting abandoned farm lands, in mixed forest it is generally inferior to its associates and should be removed. Its great vigor as a sprouter following clear cutting indicated that it would aggressively resists efforts to remote it, so study of this problem was begun in1950.

A year ago it was reported that sprouting vigor was affected considerably by the size of the canopy opening above the stumps. Re-examination of the same 50 stumps this year, 2 years after cutting, showed that almost no new sprouts were produced and the height growth of those produced during the first year has since been negligible. These findings apply both to solitary stumps and those connected to a living clump.

The explanation lies in the fact that the canopy openings above these clumps, which initially ranged up to 10 feet in diameter, averaging about 6 feet, have now almost all closed as a result of crown development by the adjacent trees. Although almost no stumps have died, they may be no problem, because growth of the sprouts can apparently be prevented indefinitely by maintenance of a dense canopy above. The elimination of pomarrosa from mixed forest does not appear difficult, particularly where advanced reproduction of desired species is present. On the other hand, the conversion of a pure pomarrosa stand to another species will require frequent cleanings until the desired species dominates.

Teak silviculture tested in two sites

Past reports have shown that teak (*Tectona grandis* L.) generally demands better sites than Puerto Rico can spare from food and forage production. Because of the great value of teakwood, however, and the fact that plantation growth on good sites is spectacular, it has been planted and is being studied on sites generally considered "too good for trees." Only through such studies will it be possible to prove whether it can compete economically with other crops.

In the Cambalache Experimental Forest (sea level; precipitation 55 inches annually) on the north coast there is a considerable area of level land between small limestone hills. Here the soil is deep and is a red lateritic clay. Previously some of this area produced sugar cane. About 5 acres were planted with teak in late 1950. Half of the area was leased to farmers for intercultivation for two years. The other half was kept weeded within 18 inches of each tree. At the end of 2 years there is little apparent difference in development due to the type of weeding. The intercultivated teak is less uniform than that elsewhere, possibly a result of root damage caused by cultivation. Both plantations average about 12 feet in height. (See Fig. 8).

An older plantation, also on a good site, is located within the Carite Forest (300 feet elevation; precipitation, 89 inches annually) on a stony alluvial soil. This plantation, 16 years old this year, has an average diameter of 7.4 inches (100 dominant and codominant trees). Mean annual basal area growth per tree for dominant and codominant trees for the first 13 years (to 1949) was 0.0219 square feet. In the past 3 years it has

Fig. 7.—Young broadleaf mahogany (Swietenia macrophylla King) trees 1 year after underplanting beneath a stand of casuarina (Casuarina equisetifolia Forst). (Arboles júvenes de caoba hondureña un año después de subplantados bajo un rodal de casuarina).

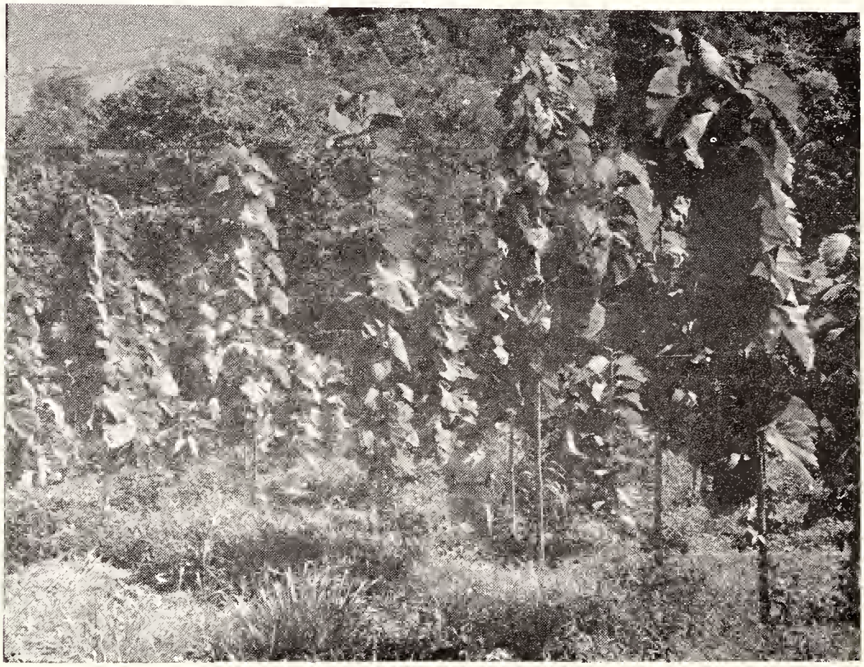

Fig. 8.—Two-year-old plantation of teak (Tectona grandis L.) established with intercultivation on an excellent soil in the Cambalache Experimental Forest. (Plantación de teca de 2 años de edad establecida con intercultivación en suelo fértil en el Bosque de Cambalache).

been only 0.0059 square feet showing that the stand is too crowded. About 40 percent of the trees were intermediate or suppressed and growing less than half as rapidly as the dominants and codominants. A quarter-acre plot was thinned from 124 to 94 square feet of basal area per acre, removing 204 trees per acre. All of the suppressed trees and about half of the intermediates were removed. Measurements will be made in the future to show the effect of this thinnning.

Mesquite outgrown by West Indian mahogany on south coast

Mesquite (*Prosopis juliflora* DC) became naturalized in Puerto Rico years ago and has invaded the forests of the dry limestone hills along the Southwest Coast. It now dominates the forest in a valley within the Guánica Forest (elevation, 100 feet; precipitation, 30 inches annually). The facts that it has invaded the natural forest and that it sprouts vigorously led to the conclusion that it was rapid growing and might be a highly productive source of posts and ties. Four years ago measurements showed the growth of this tree to be slower than had been expected. It was concluded that the rapid initial growth diminishes at an early age, before the trees attain post size.

Remeasurement of 24 tagged dominant and codominant trees within the Guánica Forest during this year provided more reliable data as to their growth. The results of these measurements, and a comparison with those for West Indian mahogany (*Swietenia mahagoni* Jacq.) are provided in Table 10. This mahogany is a 20-year old plantation growing in a comparable valley within the same forest. The data shown are for dominant and codominant trees only. Both stands are closed and of a comparable density. It is seen that the mesquite is growing more slowly than the mahogany. Since the latter species produces by far the more valuable products it should replace the mesquite, at least on the deeper soils where large trees can develop. No further research on mesquite is proposed as present.

Primavera fails to grow in the limestone region

Primavera (*Tabebuia donnell-smithii* Rose) is one of the most valuable timbers of Central America. There, on the west coast, it grows rapidly on good sites, either underplanted or in the open. An introduction 5 years ago produced a few trees which when planted on a well drained deep soil in the Luquillo Forest (elevation, 800 feet; precipitation, 120 inches annually), grew very rapidly, so additional seed was imported last year.

Experimental plantings of 400 seedlings each were established beneath an open canopy in the Cambalache Experimental Forest (sea level; precipitation, 55 inches annually) and the Río Abajo Forest (elevation, 500 feet; precipitation, 80 inches annually). On both sites the soil, although fertile, is shallow, ranging from 6 to 18

Table 10.—Mesquite and mahogany growth at Guánica

Species	Number of trees	Avg. diam at breast height		Avg. annual diam. growth
		7 years ago	Now	
		Inches	Inches	Inches
Mesquite	24	4.7	5.6	0.13
Mahogany	59	4.1	5.4	0.19

inches in depth. These trees have made no growth during the first year. The new leaves are small, thin, and chlorotic and appear as though attacked by a mosaic disease. With few exceptions this condition is universal, and not related to the amount of light received. The only apparent explanation is the soil, which is less acid (pH 6) and shallower than where the trees are growing well. An attempt will be made to determine the deficiency.

The older plantation in the Luquillo Forest is now from 30 to 45 feet tall and very thrifty. Trees in the open are 3 to 5 inches in diameter. Trees in a new planting on this site range from 10 to 15 feet in height at the end of the first year.

Hat palm establishment proves slow

The Puerto Rican hat palm, (*Sabal causiarum* (Cook) Beccari) has been an important basis for a local hat industry. The source of palm leaves was greatly reduced by the reservation of a large palm area for military purposes. In an effort to increase production the artificial regeneration of this palm has been investigated. Production of nursery stock required 24 months. Some of this stock was planted in 1946 in the Cambalache Experimental Forest (sea level; precipitation, 55 inches annually) on clay loam soil similar to that where the trees are native. Growth has been very slow, the palms attaining from 2 to 5 feet in height in 6 years. For 3 years they were of poor color and almost entirely inactive. The first usable leaves were produced after 5 years. The productivity of this species is low and does not appear to warrant further research at this time. A few palms are being propagated by the Forest Service for small plantings about rural homes.

Seed of 53 species imported

The need for new, more productive forest crops has made desirable the testing of exotic species to determine their adaptability and productivity in Puerto Rico. About 120 exotic tree speces have been tested by the Station in the past 13 years. During this year seed of 53 species was imported from tropical and subtropical regions throughout the world. Twenty-seven of these species are introductions new to Puerto Rico. Species imported included 12 gymnosperms and 24 species of eucalyptus. Seed weights were determined for 24 species.

Increasing the utility of wood

Insects and decay both important in post cutting time study

There is a widespread deep--seated belief in Puerto Rico (as in other tropical areas) that wood varies in durability with the time of cutting. Common explanations include moon phases, tides, or seasons of the year. Although studies elsewhere have mailed to show that time of cutting, as such, has any effect on the durability of wood, a study taking into account these factors appeared to be of value at least for demonstration purposes. A year ago the Station undertook a study of this nature in which the following variables were included: site, species, moon phases, season of the year, tides weather, and whether the trees were dormant or growing. A total of 1,800 posts were included in this experiment and were set in the Toro Negro and Cambalache Forests.

At the end of the first 12 months a complete inspection was made to determine the presence, nature, and extent of deterioration. It was found that no post had become unserviceable and it was not yet possible to analyze the effect of different treatments. Nevertheless agencies of destruction were active in nearly half of the posts. Insect damage appeared to be more important than decay. The most common insects were powder post beetles and wood borers. Locally there was also some termite damage.

A total of 1,300 of the posts have been re-examined after 18 months (as will be continued each 6 months thereafter). At this time each post was subjected to a moderate push to determine its serviceability. In all, 575 posts broke off, but no marked difference among the treatments is yet apparent. Weakening of these posts, whether caused by insects or decay, was greatest at the ground line. Only a few of the posts failed solely because of insect damage. Most of the posts which failed primarily because of decay had been attacked by insects. Insect tunnels were undoubtedly an important contributing factor to the progress of the decay.

Further examinations will shed additional light upon the causes of post deterioration and will make possible comparison of the different treatments.

Specific gravity and shrinkage determined for several species

In the absence of strength data from actual testing, knowledge of the specific gravity of different woods is of value in approximating several of their mechanical properties and in the estimation of shrinkage, weight per cubic foot, void volume and maximum moisture percent attainable, and withdrawal resistance of nails and screws. Shrinkage figures are used determining changes in dimensions with changes in moisture content, converting specific gravities from green to oven dry volume and conversely.

For several years the Station has been computing the specific gravity of several wood species. During this year the specific gravity of eleven species and the volumetric shrinkage of seven of these have been determined. The data appear in Table 11. As found elsewhere, the volumetric shrinkage of these tropical species is generally lower than that of woods of comparable density from temperate zones.

Table 11.—Speciific gravity and volumetric shrinkage of eleven woods

Species	Specific gravity, oven dry, based on volume		Volumetric shrinkage from green to oven dry based on green dimensions
	Green	Oven dry	
			Percent
Casuarina. *C. equisetifolia* Forst.	—	0.93	—
Balsa. *Ochroma piramidale* Sw.			
Butt log			
Heart	—	0.29	—
Sap	—	0.24	—
Upper branch	—	0.18	—
Capá prieto. *Cordia alliodora* (R & P.) Cham	0.49	0.58	15.9
Jácana. *Lucuma multiflcra* A. DC	0.76	0.88	14.2
Aguacatillo. *Meliosma herberti* Rolfe	0.44	0.51	14.0
Caimitillo, *Micropholis chysophylloides* Pierre	0.69	0.78	11.0
Laurel avispillo, *Nectandra coriaceae* (Sw.) Griseb	—	0.59	—
Caimitillo verde, *Micropholis garcinifolia* Pierre	—	0.81	—
Guaraguao, *Guarea trichilioides* L.	0.49	0.57	13.6
Capá blanco, *Peticia domingensis* Jacq.	0.55	0.61	10.2
Mamey. *Mammea americana* L.	0.66	0.76	13.1

Considerably more effort is to be placed on this project during the next few years. A difficulty that has attended past work has been the lack of good equipment for volumetric measurement. This deficiency is to be corrected during the coming year.

Untracted Eucalyptus fence post serve for three years

Eucalyptus (*E. robusta* Smith and *E. kirtoniana* F. v. M.) has proven so well adapted to the central mountains of Puerto Rico that various studies of its utilization have been undertaken. One of the first studies of this nature concerned the durability of these species for fence posts, started in 1949. Twenty posts were set in a well drained deep soil in a fence within the Guilarte Forest (elevation, 3,000 feet, precipitation, 110 inches annually). The posts were 4 to 5 inches in diameter.

This year (3 years after installation) 11 posts broke off when subjected to moderate push, and the others which resisted were very weak.As these posts were slightly larger than those normally used it is safe to conclude that the average life of untreated fence posts of these species is not more than 3 years in this environment. The desirability of developing preservative treatment is clear, and studies described elsewhere in this report are directed to that end.

Zinc chloride treated posts attacked by insects

The introduction of wood preservation as a practice in rural areas requires simple techniques applicable with a minimum of cost and on a small scale. A search for such techniques led in 1951 to the testing of the end diffusion process, which is applicable to green unbarked wood. The preservative tested was copperized chromated zinc chloride, said to be relatively resistant to leaching.

Three common post species of the mountains were tested, eucalyptus (*E. robusta* Smith, and *E. kirtoniana* F. v. M.) and guaba (*Inga vera* Willd.) Sixteen posts of each species were treated. The chemical was used in a 25 percent aqueous solution. The posts were left in the solution until they had absorbed 1 pound of chemical per cubic foot of wood, a period which varied from 7 to 21 days. Shorter periods were necessary during dry weather. To determine the depth of penetration, several posts were split open and sprayed with equal parts of a 1 percent potassium ferricyanide solution, a 1 percent potasium iodide solution, and a 5 percent solution of soluble starch. The preservative was found to be confined to the outer sapwood and the lower 24 inches of the posts. The treated posts were inverted and dried for 3 months before setting.

After 1 year, all treated eucalyptus posts are severely attacked by termites whereas all untreated posts are sound. No insect damage appears on any of the treated or untreated guaba posts but one treated post shows incipient fungus development.

Although service records on zinc chloride treated material are numerous in the States no such records were found on copperized chromated zinc chloride which is a relatively new product. Evidence from this experiment strongly points to more favorable termite development in eucalyptus in the presence of copperized chromated zinc chloride. The termite attack began in the bark and spread into the wood. Further tests will be made with this and other preservatives to determine effectiveness without bark, and how to obtain better penetration.

Carbolineum-treated posts of three species sound after two years

The most successful test of preservation of posts at the Station is one made in 1944 when several posts of casuarina (*Casuarina equisetifolia* Forst) were treated with carbolineum by the hot-cold bath method. These posts are still sound.

It was decided to test the same treatment with three common species of posts.

Eucalyptus robusta Smith, *E. kirtoniana* F. v. M.. and *Micropholis chrysophylloides* Pierre. The posts were dried to a moisture content below 30 percent after which they were placed in hot carbolineum (100ºC) for 4 hours and allowed to cool for 16 hours. Preservative absorption varied from nearly 6 to almost 8 pounds per cubic foot of wood. Half of the posts were set in the Toro Negro Forest (elevation 2,500 feet; precipitation, 110 inches annually) and half in the Cambalache Experimental Forest (sea level; precipitation, 55 inches annually) Untreated *E. robusta* controls were set on both sites.

All treated ones are still completely sound 2 years after setting. The preservative appears to be leaching out of some of the posts. Half of the untreated *E. robusta* posts have failed. Probably none of the untreated posts will last longer than one more year. On the other hand, the service life of the treated posts will certainly be much longer.

Future experiments of this nature will utilize coal-tar creosote (which is cheaper than carbolineum) and will be directed toward the economic aspects of such treatment.

PLANS FOR 1953

Developments during the past year point strongly to the need for greater emphasis on investigations of forestry practices which are practical for private forest lands. This will involve not only the retesting on such lands of species and techniques already found satisfactory elsewhere, but also companion experiment directed toward opening markets to a degree that trees can be considered a short-rotation cash crop.

Specifically, cooperative studies of the pulping properties of eucalyptus, coffee shade trees, and a few other common species are proposed. Extensive testing of eucalyptus establishment with intercultivated crops is to be done on private lands. The use of more productive shade trees for coffee should also be tried on private lands. Efforts will also be made to get a pressure-treatment plant set up for the preservation of both imported and domestic poles, piling, timbers, and ties. Closely related activities proposed include a public exhibit of local forest products, surveys of forest products consumption and waste by local industries, seasoning practices, the use of wood preservation, and service life. To encourage forestry on private lands, formal demonstration areas are to be set up within public forest areas representative of private lands. Plans for the development of these areas are to be drawn up jointly with the Extension Forester and the use of the areas is to be primarily by the Extension Service. In addition, the survey of established plantations on private lands begun 2 years ago is to be completed. The results are to be incorporated into a bulletin on tree planting.

The new work proposed will require a reduction in emphasis on some past projects. A large number of adaptability tests were terminated at the close of this year, and revision of the re-examination schedule has resulted in an additional saving in time. A manual standarization certain research procedures and techniques on the basis of all past experience should further increase efficiency. A revision of the problem analysis and working plans is to be completed early in the year.

(Traducción del artículo anterior)

Decimotercer Informe Anual de la Estación de Experimentación Forestal Tropical

El año de 1952 se señaló por un uso más intenso que nunca de los trabajos de investigación. Por primera vez en 10 años se recomendó la siembra en gran escala de los montes públicos. Con anterioridad a esta fecha se habían sembrado 22.000 acres de bosques públicos, pero estas siembras en gran escala se descontinuaron debido a los muchos fracasos y al alto costo de las mismas. La pauta a seguir luego ha sido observar las siembras anteriores y hacer minuciosas pruebas de nuevas especies, técnicas y ambientes estacionales. Aún hoy sólo podemos recomendar con seguridad un número limitado de estas prácticas. Un resultado de estas recomendaciones ha sido la subplantación este año de más de 2.000 acres de bosques secos en la costa sur de caoba antillana (Indias Occidentales) y 450 acres de bosques pluviales en caoba hondureña. Varios miles de acres de sitios similares a los anteriores serán subplantados tan pronto lo permitan los fondos.

Una consecuencia importante ha sido la demanda por eucalipto para pilotaje. Los primeros 30 pies de árboles de 12 pulgadas (de 14 años) valen $4.50 en pie. Estas y otras perspectivas para la utilización de este árbol por su celulosa han hecho desaparecer las dudas en cuanto a la plantación en gran escala del eucalipto en elevaciones entre 2.000 y 3.000 pies. Los bosques secundarios naturales que se encuentran entre las plantaciones se dedicarán al eucalipto. La siembra del eucalipto por el sistema taungya será cuidadosamente investigada el año próximo. Si los resultados son satisfactorios ésto podría fomentar la siembra de árboles en terrenos particulares.

LA REORIENTACION DEL PROGRAMA DE INVESTIGACION

Un punto culminante entre los acontecimientos del año lo fué la visita del Dr. V. L. Harper, Jefe Auxiliar del Servicio Forestal a cargo de la investigación de bosques y del Dr. H. G. Wilm a cargo de la División de la Investigación de las Influencias Forestales, ambos de Washington. Estudiaron detenidamente los problemas forestales de la isla y el programa actual de la Estación. Hicieron recomendaciones de gran valor para la orientación del trabajo. Es probable que como resultado de su visita se incluya formalmente en el programa de la Estación la utilización de bosques y la investigación de influencias forestales.

Un estudio de la utilización de bosques en Puerto Rico se hizo a solicitud de la Estación por el Sr. C. C. Bell, Jefe del Servicio de Utilización de Bosques del Laboratorio de Productos Forestales. Después de 4 semanas de estudio en la isla, el Sr. Bell hizo entre otras, tres recomendaciones básicas en torno a la utilización de bosques, sus productos, conversión de madera y fábricas: (1) mayor uso del material inferior en tamaño, calidad y forma, (2) aumento en la producción de madera de aserraje, de buena forma y de especies valiosas y (3) aceleración en las pruebas de fábrica y experimentos de campo que han de aumentar los pocos conocimientos que ahora tenemos sobre las propiedades y usos de las maderas de Puerto Rico. El Sr. Bell recomendó un amplio programa de investigaciones sobre utilización industrial, pulpa y papel, relaciones selviculturales, física de la madera de aserraje y conservación de maderas, para ser llevado a cabo en la Estación pero con la cooperación del Laboratorio.

Con el nombramiento por el Servicio Forestal de Puerto Rico del Sr. Miguel Hernández Agosto, un selvicultor profesional, para ayudar en el programa de investigación de la Estación se le ha dado un verdadero

empuje al estudio de la utilización de bosques. Dicho Servicio también ha provisto al Sr. Hernández de un fondo para la compra de material y equipo. Al Sr. Hernández se le ha designado para el trabajo de investigación en el campo de la utilización de bosques por su pericia en ese ramo y por la necesidad de estudio que hay en ese campo que hasta la fecha ha tenido menor importancia en el programa de la Estación. El se ha hecho cargo de todas las investigaciones en progreso y ha instrumentado un programa de largo alcance que resultará en mayores conocimientos en cuanto a la calidad y cantidad de los productos forestales a mano en Puerto Rico; nuevos usos para estos productos y mayor durabilidad de servicio. El Sr. Hernández hizo arreglos para un acuerdo de cooperación, firmado este año, entre los Servicios Forestales y el Colegio de Agricultura de la Universidad de Puerto Rico para investigaciones conjuntas sobre madera de construcción, química de la madera y patología de los productos.

ACTIVIDADES DE ALCANCE INTERNACIONAL

Oficiales de la administración de la Estación hicieron tres viajes a países extranjeros. El Jefe de División sirvió como representante de los Estados Unidos en el comité organizador para una conferencia que estudiaría el mercado maderero y que se llevaría a cabo bajo los auspicios de la Comisión del Caribe. El comité organizador se reunió en Puerto España y recomendó una agenda, apuntes y otros trabajos para ser hechos por la Secretaría con antelación a la conferencia que está señalada para abril del 1953. El director pasó una semana en la República Dominicana donde discutió con el Ministro de Agricultura los problemas forestales de aquel país y los programas forestales en curso.

El Jefe de División asistió como delegado de Estados Unidos a la cuarta sesión de la Comisión Forestal de la F.A.O. de la América Latina en Buenos Aires. A su regreso se detuvo una semana en Sao Paulo, Brasil visitando extensas plantaciones de eucalipto de la Companhia Paulista de Estradas de Ferro. También visitó los bosques del río Essequibo en la Guayana Inglesa y los de Grenada, Santa Lucía y Dominica en las Antillas Menores inglesas. Estas paradas proporcionaron valiosa información sobre el eucalipto, la ecología de los bosques pluviales y árboles de especies exóticas con las que valdría la pena ensayar en Puerto Rico.

El año pasado la Estación fué visitada por 14 selvicultores de 13 países extranjeros. Además cinco estudiantes de selvicultura recibieron adiestramiento en la Estación. Para tres de éstos que permanecieron en la Estación 5 meses, fué posible prepararles un programa de estudios bien equilibrado que cubría muchas fases de selvicultura. Dos de estos estudiantes eran graduados de la Universidad de los Andes, Mérida, Venezuela.

Algunas ediciones del Caribbean Forester se retrasaron de manera que el número de octubre está aún en prensa. Este año se publicaron siete artículos sobre la Argentina, el Brasil, las Islas Vírgenes y Puerto Rico. Más de la mitad de las páginas se dedicaron a informes sobre el trabajo de investigación de la Estación. La lista de envíos contiene 746 nombres, la mayor parte extranjeros.

Por solicitud de la cuarta sesión de la Comisión Forestal de la F.A.O. de la América Latina, el glosario español-inglés de términos de selvicultura que ha estado en preparación en esta Estación durante los últimos 10 años será sometido, aunque aún sin terminar, a la oficina forestal de la F.A.O. de la América Latina en Río de Janeiro para su distribución y crítica en los países Sudamericanos de donde será devuelto a la Estación para su revisión. Este año se han añadido las definiciones de 109 palabras del español haciendo un total de 802. Esto es aproximadamente la mitad del número de términos del inglés ya definidos.

ACTIVIDADES LOCALES

Por iniciativa de la administración se preparó un informe sobre los recursos forestales

de Puerto Rico y se hicieron las recomendaciones pertinentes para su uso y desarrollo. Por medio de mapas topográficos se determinaron las áreas críticas de cuencas hidrográficas, se hizo un análisis de los actuales programas de conservación y se consideraron medios prácticos para mayor adelanto forestal. El informe recomienda específicamente mayores conocimientos forestales y ayuda técnica, la pronta adquisición de bosques para propiedad pública, más investigaciones forestales, incentivos para propietarios particulares proporcionados a los de otras prácticas de conservación y cuidadosa consideración de la legislación reglamentaria para áreas críticas. El informe apenas alterado se ha incorporado como capítulo VI de "A comprenhensive agricultural program for Puerto Rico" que será publicado dentro de poco por el Departamento de Agricultura de los Estados Unidos.

El Dr. Elbert L. Little Jr., de la División de Investigaciones sobre Dendrología, Pasto y Forraje del Servicio Forestal de Washington pasó 3 meses en Puerto Rico a solicitud de la Estación para continuar el manuscrito en lenguaje corriente de dos libros descriptivos sobre los árboles de Puerto Rico. Durante una visita anterior el Dr. Little había recogido material herbario suficiente para un volumen en el que se describen 250 especies. Este año él casi terminó el texto descriptivo de 475 especímenes que se montaron en el herbario. Sólo resta hacer los dibujos de algunas especies.

Este año se continuó cooperando con el Servicio de Conservación de Suelos para estimular la plantación de bosques en las Islas Vírgenes. Se formularon planes detallados para un programa de extensión, recolección de semillas, preparación de suelos, propagación, sementeras y plantaciones. Se deslindaron bosques en cuatro propiedades particulares y se les hicieron recomendaciones explícitas a los propietarios. Además se preparó un proyecto sobre la propagación de árboles con trabajo específico para 7 meses distintos del año que posiblemente podrían llevar a cabo los Clubes 4-H. Tres pequeños cuarteles de crecimiento se establecieron en rodales naturales de caoba antillana. A pesar del interés del Gobernador, este programa adelanta poco. Puede que tenga mayor éxito el programa propuesto para el año próximo por la Corporación de Islas Vírgenes en cooperación con el Servicio de Conservación de Suelos y la Estación.

La reunión de campo que se celebró el 22 de mayo en el Bosque Experimental de Cambalache, fué un evento sobresaliente. Alrededor de 120 personas participaron, incluyendo representantes de las siguientes agencias relacionadas con terratenientes: Servicio de Conservación de Suelos, Servicio de Extensión Agrícola, Administración de Producción y Mercadeo, Departamento de Agricultura y Comercio de Puerto Rico, Juntas de Distrito de Conservación de Suelos, Autoridad de Tierras de Puerto Rico, Administración de Hogares Rurales y los Servicios Forestales Federal y de Puerto Rico. También asistieron unos 30 niños de grados superiores de una escuela vocacional cercana y 10 prominentes agricultores del distrito. Los problemas forestales de la costa norte de Puerto Rico se presentaron por medio de demostraciones y explicaciones ofrecidas por representantes del Servicio de Extensión, del Servicio de Conservación de Suelos y de los dos Servicios Forestales. Se mostraron numerosos plantíos de diferentes especies, unos plenamente logrados y otros aún en estudio, como también una demostración de corta de mejora.

Otros ejercicios educativos del año incluyeron conferencias sobre investigaciones y conservación de bosques ofrecidas a estudiantes de dasonomía del Colegio de Agricultura, a niños de la Escuela Naval, a unos 100 guías en el Campamento de Niños Escuchas y al Club de Jardinería.

La administración organizó un curso de adiestramiento de una semana para 25 del personal de los dos Servicios Forestales. Parte del curso giró en torno a asuntos administrativos solamente, pero se les explicó detalladamente la base biológica de la selvicultura, la necesidad de investigaciones,

experimentos en curso y los resultados obtenidos hasta la fecha y que tienen alguna importancia para ellos. También se les mostraron cinco experimentos de campo de mayor importancia.

El Sr. Marrero ha seguido poniendo en uso los resultados de investigaciones al delinear y dirigir el programa de regeneración del Bosque Nacional del Caribe. Esto envuelve la exploración y señalamiento de áreas de mayor prioridad para plantíos, cuido de plantaciones, mejoramiento de rodales, recomendación de técnicas, inspecciones y la preparación de un informe anual. Durante este año se han tratado 2.040 acres que incluyen la siembra de 810 acres y el cuido de 1.230 acres de plantaciones. Similar pero menos detallada ayuda se le ha dado a los programas más extensos del Servicio de Bosques de Puerto Rico. La administración ha servido también en una comisión encargada de mejorar la distribución de árboles a los agricultores. Las recomendaciones comprenden la aplicación directa de los hallazgos de investigaciones relacionadas con técnicas de propagación, especies a propagar y el medio estacional a que éstas se adaptan.

Este año se ha recibido en la biblioteca un total de 763 obras nuevas. Se ha terminado de catalogar una acumulación de adquisiciones recibidas anteriormente. La biblioteca contiene ahora 6.850 obras que tratan de selvicultura tropical o de otros campos estrechamente relacionados a éste. La administración tiene también a su disposición la biblioteca de la Estación Experimental Agrícola de la Universidad que es mucho más grande y queda a 500 pies de la oficina central de la Estación.

El personal de la administración de la Estación es pequeño y el adelanto ha dependido grandemente de la ayuda de numerosos cooperadores. La cooperación recibida del exterior incluye la orientación ofrecida por los dos jefes de investigación de Washington, el estudio sobre la utilización de bosques por el Laboratorio de Productos Forestales, y el progreso hecho en el manuscrito de "Trees of Puerto Rico" por un miembro de la oficina del Servicio Forestal en Washington. Los territorios británicos del Caribe hicieron una contribución en efectivo para el Caribbean Forester. Otra contribución de gran importancia ha sido la de semillas de nuevas especies de árboles recibidas de todas partes del mundo. A cambio de instrucción, los estudiantes extranjeros de dasonomía han sido de gran ayuda en trabajos de campo.

El Bosque Nacional del Caribe y el Servicio Forestal de Puerto Rico contribuyen al establecimiento, protección y mantenimiento de las instalaciones experimentales; proporcionan sitios convenientes y el uso de estaciones de campo en Puerto Rico. El Servicio Forestal de Puerto Rico también propaga la mayor parte de los árboles que se usan en experimentos de regeneración. El nombramiento del Sr. Hernández para la Estación, como se ha dicho, es otra gran contribución beneficiosa de parte de esta agencia. La Universidad de Puerto Rico ha sido otro importante cooperador, facilitando el uso de su biblioteca y a través de la Estación Experimental Agrícola ha cedido a la Estación el Bosquecillo de Río Piedras y ha prestado ayuda directa en el trabajo de experimentación, particularmente en los campos de entomología y diseño experimental. El Servicio de Extensión Agrícola ha proporcionado servicios fotográficos que a veces requirieron el empleo de su fotógrafo por un día o más. Además este Servicio ha hecho arreglos para la publicación en la prensa y por la radio de charlas dictadas por miembros de la administración. Conjuntamente el Servicio de Extensión, el Servicio de Conservación de Suelos y la Junta de Supervisores de Distrito de Conservación de Suelos hicieron posible el día de campo en Cambalache, reuniendo personas clave, allegando fondos, ocupándose de la comida y suministrando información al grupo allí reunido. El reexamen de las plantaciones en La Mona pudo hacerse gracias a la transportación y hospedaje que ofreció el Servicio de Guardacosta Federal.

RESULTADOS DE INVESTIGACIONES

El trabajo experimental de la Estación se ha llevado a cabo en distintas áreas forestales de la isla de Puerto Rico. La mayor parte de los estudios se hacen en montes del Estado, bien del Gobierno Federal o del Insular. (Véase ilus. 1). No todos los hallazgos del año se consideran suficientemente importantes para ser discutidos en este informe. Algunos de los estudios informados hace un año no han progresado lo bastante para merecer otro informe. Sólo se describirá el progreso alcanzado durante los dos o tres últimos años en algunos estudios que no han sido informados recientemente.

Los bosques de experimentación continúan siendo centros para gran parte de las investigaciones selviculturales. Los bosques de Cambalache y St. Just son de gran utilidad a la comunidad como fuentes de productos madereros. En Cambalache se hicieron 25 ventas de madera de aserraje que incluían 2.500 pies cúbicos de rollizos por $275. Del mismo bosque 90 familias de los alrededores sacaron gratis 11.018 haces de leña o sea un volumen de 110 cuerdas de madera* (14.080 pies cub.) Del área experimental de St. Just 20 familias sacaron 1.407 haces de leña equivalentes a 14 cuerdas de madera (1.792 pies cúbicos). Del bosquecillo de Río Piedras se le suministraron 850 postes para cercas a la Estación Experimental de Agricultura de la Universidad de acuerdo con el plan para la administración de este bosque.

Los experimentos se clasifican aquí según sus objetivos principales. Estos comprenden la determinación de:

1. Extensión y naturaleza de los bosques de Puerto Rico.
2. Contribución actual y potencial de los bosques de Puerto Rico.
3. Métodos prácticos para aumentar la productividad de los terrenos forestales.
4. Métodos prácticos para aumentar el aprovechamiento de la madera.

La mayor parte de la investigación selvicultural informada comprende estudios sobre el crecimiento de los árboles con relación a su situación. El único método satisfactorio para llevar a cabo estos estudios dentro de los bosques naturales o antiguas plantaciones ha sido el establecimiento de cuarteles permanentes en rodales que satisfacen las condiciones deseables. En el curso de este año pasado se midieron de nuevo 25 de estos cuarteles y se establecieron 12 más.

Al finalizar el año una revisión crítica de un gran número de estudios sobre la adaptabilidad de diferentes especies de árboles al ambiente estacional, dió por resultado la eliminación de más de 100 de éstas. Muchas ya habían dado toda la información que podía esperarse y otras era obvio que habrían de fracasar. Esto constituye una economía considerable en el volumen de reexamen y observación, dejando así a los miembros de la administración más libres para hacer estudios ulteriores de mayor importancia.

El Sr. Hernández Agosto adscrito al Servicio Forestal de Puerto Rico preparó los informes relacionados con la producción forestal y la utilización de la madera que han estado bajo su dirección durante los últimos 6 meses. En éstos se alude frecuentemente a informes previos de la Estación.

Informes recientes se publicaron en The Caribbean Forester en las fechas siguientes: 1949, 11:59-80; 1950, 12:1-17; y 1951, 13:1-21.

Area aproximada de terrenos forestales

En el trabajo de investigación forestal los conocimientos en cuanto al área, situación y naturaleza de los mejores terrenos apropiados para el desarrollo de bosques son esenciales. En el pasado ha habido en Puerto Rico informes en este sentido, pero poco confiables. Por consiguiente para la preparación de un informe sobre los recursos fores-

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* Medida de cubicación que se usa para medir leña y que equivale a 128 pies cúbicos de madera.

tales y recomendaciones pertinentes para la adquisición de montes, se ha tratado de localizar y determinar el área de los terrenos en los cuales los árboles habrían de dar rendimiento continuo y mayor (desde el punto de vista económico y/o social) que otras cosechas.

Los árboles se dan en todo Puerto Rico, aunque en la mayor parte de la isla económicamente dan menos rendimiento que otras cosechas. Datos insuficientes hacen imposible la comparación clara entre los beneficios económicos de productos forestales y no forestales. Sin embargo hay una clase de terreno casi unánimemente aceptada como la mejor para árboles: aquellas áreas que debido a un declive extremo (50% o más); a fuertes lluvias; o a terreno bajo, estéril o de drenaje insuficiente no sirven para cultivo o pastoreo continuo sin deterioro de su suelo y/o poco rendimiento, empero pueden producir árboles como cosecha permanente.

Todas las áreas con declive mayor de 50 por ciento, han sido indicadas en los mapas topográficos de la isla. Por planimetría se ha encontrado que éstas comprenden aproximadamente 600.000 acres o sea la cuarta parte de la superficie de los terrenos de la isla. De esta área como 427.000 acres se reparten en lotes de 10.000 o más acres cada uno, que se prestan para una ordenación forestal efectiva. Estos lotes están situados como se ndica en la Ttabla 1. (Véase ilus. 2).

Tabla 1.—**Las áreas mayores de terrenos forestales en Puerto Rico**

Situación	Area forestal
Región caliza del norte	90.000
Pendiente sur de la Cordillera	83.000
Sierra de Cayey	60.000
Sierra de Luquillo	47.000
Valle del Río Manatí	33.000
Valle del Río Arecibo	29.000
Sierra de Atalaya	25.000
Valle del Río La Plata	23.000
Guánica	16.000
Tallaboa	11.000
Lajas	10.000
Total	427.0000

El remanente de los terrenos forestales está en predios menores pero debiera ofrecer importantes fuentes locales de productos madereros. Estos datos sirvieron de base para un programa para la adquisición de montes para propiedad pública.

Se establece lentitud de crecimiento en selvas vírgenes

En Puerto Rico se han hecho estudios de los pocos bosques vírgenes que restan para determinar la naturaleza de estas selvas y la de los árboles que las integran y así establecer lo que puede esperarse de los diferentes tratamientos selviculturales. En los últimos tres informes se han ofrecido los primeros datos relacionados con los requisitos de estancia, tolerancia y crecimiento relativo de las varias especies en los bosques no explotados.

Mediciones de crecimiento hechas en un gran número de árboles en los tipos tabonuco y colorado de las Montañas de Luquillo[1/] (bosque pluvial pedemontano y bosque montano) llevaron hace algunos años a la creencia de que el crecimiento diametral en los árboles en los bosques pluviales vírgenes era muy lento. El período de medición entonces era sólo de 2 años y no se llegó a conclusión definitiva alguna. Por esta razón, 5 años más tarde, en 1952, se hizo una segunda medición.

Los resultados de esta segunda medición aparecen en la Tabla 2. Los datos sobre el tipo tabonuco cubren 399 árboles de 10 especies de dosel: tabonuco (*Dacryodes excelsa* Vahl), aguacatillo (*Meliosma herberti* Rolfe), ausubo (*Manilkara duplicata* (Sessé & Moc) Dubard), caracolillo (*Homalium racemosum* Jacq.) granadillo (*Buchenavia capitata* (Vahl) Eichl), guajón (*Beilschmedia pendula* (Sw.) Nees.), masa (*Tetragastris balsamifera* (Sw.) Kuntze), motillo (*Sloanea berteriana* Choisy), nuez moscada (*Ocotea moschata* (Pavon) Mez.) y roble (*Tabebuia pallida* Miers). Análisis

1/ Según clasificación de Beard, Climax Vegetation in Tropical América. Ecology: 25 (2) : 127-158.

Tabla 2.—**Cómputo de la edad de árboles en rodales vírgenes Bosque de Luquillo**

Diámetro a la altura del pecho	Cálculo de edades						
	Tipo tabonuco	Tipo colorado					
	Especie dosel	Caimitillo	Nemocá	Caimitillo verde	Camasey jusillo	Laurel sabino	Palo colorado
Pulgadas	Años	Años	Años	Años	Años	Años	Años
4	80	90	200	170	80	100	80
8	130	160	400	260	200	180	170
12	180	230	570	320	340	250	280
16	220	290	700	370	440	340	420
20	260			430		430	580
24	300					540	730
36	420						1200

por separado demostraron que en las selvas vírgenes la proporción de crecimiento entre las varias especies era muy poca para merecer separación entre ellas. Más de la mitad de los árboles (222) eran del tabonuco común prevaleciente.

Del tipo colorado se midió un número mayor de árboles de las especies comunes grandes y se tiró una curva con los datos sobre cada una. Había 480 árboles de caimitillo (*Micropholis chrysophylloides* Pierre), 260 de nemocá (*Ocotea spathulata* Mez), 832 de caimitillo verde (*Micropholis garcinifolia* Pierre), 828 de camasey jusillo (*Calycogonium squamulosum* Cogn.), 171 de laurel sabino (*Magnolia splendens* Urban) y 171 de palo colorado (*Cyrilla racemiflora* L.).

Se tiró la curva del grado proporcional de crecimiento sobre la del diámetro de los árboles y entonces se calculó la edad de los árboles de distintos diámetros sumando los períodos necesarios para pasar de una clase diametral a la siguiente.

En la Tabla 3 se indica de distinta manera el crecimiento diametral lento de los árboles más importantes de estas selvas vírgenes y está basado en el análisis de 2.488 árboles de especies que alcanzan gran tamaño. Los datos presentados se refieren a árboles de 2 a 20 pulgadas de diámetro según mediciones de hace 5 años. La Tabla 3 indica como los árboles dominantes crecen más lentamente que los codominantes del tipo tabonuco, aparentemente debido a su mayor edad.

Tabla 3.—**Crecimiento diametral en rodales vírgenes, Bosque de Luquillo**

Clase según la copa	Tipo Tobonuco		Tipo Colorodo	
	Número de árboles	Crecimiento diametral promedio anual	Número de árboles	Crecimiento diametral promedio anual
		Pulgadas		Pulgadas
Dominante	27	0,10	123	0,05
Codominante	64	0,13	212	0,05
Intermedio	240	0,13	567	0,04
Dominado	339	0,05	952	0,03
Todos	634	0,09	1854	0,04

El incremento anual bruto (sin excluir la mortalidad) de dos cuarteles de un acre en bosque virgen de tipo tabonuco fué de 60 pies cúbicos por acre y el de ocho cuarteles de un acre cada uno en bosque de tipo colorado, fué de 28 pies cúbicos por acre.

El crecimiento lento dentro de los bosques vírgenes demuestra la magnitud de la tarea del selvicultor para hacer de éstos áreas de alta producción. No sólo habrá que eliminar los árboles inferiores en especie y forma sino que habrá que multiplicar por mucho el crecimiento para que la dasonomía rinda ingresos.

Se determina el ritmo de crecimiento relativo de diferentes especies de Luquillo

Los bosques actuales en Puerto Rico se pueden mejorar mucho sencillamente con cortas parciales que dejen en pie los mejores árboles. Aunque la subplantación en nuevas especies superiores promete ser un ataque más beneficioso para el mejoramiento forestal en algunos sitios, todavía no se ha comprobado que sea un éxito completo. Mientras tanto, tendremos que depender de los mejores árboles que ahora crecen en estos rodales. En la evaluación de estas especies se deberá tomar en consideración un número de características entre las cuales una de las más importantes es el ritmo de crecimiento.

Durante este año se consultaron todos los estudios sobre crecimiento, ya registrados, de las principales especies de madera de construcción y postes dentro de los tipos tabonuco y colorado de las montañas de Luquillo con el fin de hacer una comparación de sus ritmos relativos de crecimiento. Los datos presentados en la Tabla 4 son de árboles codominantes e intermedios de clase según la copa (igual peso para cada clase) que son los más comunes en bosques bien ordenados. Se trata de árboles de 4 a 20 pulgadas de diámetro.

Tabla 4.—**Crecimiento diametral de árboles codominantes e intermedios Bosque de Luquillo**

Especies	Arboles	Crecimiento diametral promedio anual
	No.	Pulgadas
Gallina, *Alchorneoposis portoricensis* Urban	15	0,32
Negra lora, *Matayba domingensis* (DC) Radlk	85	0,20
Mato, *Ormosia krugii* Urban	47	0,27
Granadillo, *Buchenavia capitata* (Vahl.) Eichl	15	0,26
Roble, *Tabebuia pallida* Miers	36	0,25
Guamá, *Inga laurina* (Sw.) Willd.	14	0,23
Ausubo, *Manilkara bidentata* (A..DC) Chev.	40	0,20
Achiotillo, *Alchornea latifolia* Sw.	21	0,20
Masa, *Tetragastris falsamifera* (Sw.) Urban.	14	0.20
Hueso blanco, *Linociera domingensis* (Lam.) Knobl.	12	0,20
Motillo, *Sloanea berteriana* Choisy	30	0,19
Tabonuco, *Dacryodes excelsa* Vahl.	179	0,14
Yagrumo macho, *Didymopanax morototoni* (Aubl.) Dcne.	54	0,14
Nuez moscada, *Ocotea moschata* (Pavoni) Mez.	17	0,10
Roble de sierra, *Tabebuia rigida* Urban	60	0,07
Caimitillo, *Micropholis chrysophylloides* Pierre	144	0.06
Laurel sabino, *Magnolia splendens* Urban	46	0.06
Caimitillo verde, *Micropholis garcinifolia* Pierre	514	0,05
Jusillo, *Calycogonium squamulosum* Cogn.	292	0.04
Nemocá, *Ocotea spathulata* Mez.	72	0,04

Dentro de cada especie el promedio de crecimiento de distintos árboles varió considerablemente como lo hizo también la estructura de los varios rodales examinados. Sin embargo había un número de áreas ordenadas bien aclareadas. Los árboles en el último tercio de la lista crecieron tan lentamente que hay que considerarlos como árboles de baja producción a pesar del valor de su madera. Entre éstos están las especies más comunes del tipo colorado. Como se verá cualquier aumento considerable en la productividad de esta área requeriría un cambio mayor en la composición, que probablemente envolvería la regeneración artificial con especies exóticas.

Crecimiento de palmas de sierra en relación al diámetro y altura

La palma de sierra (*Euterpe globosa* Gaertn) es común en los bosques a más de 2.000 pies de elevación. En vastas extensiones (5,000 acres en el bosque de Luquillo solamente) aparece en rodales casi puros. Su valor es sólo de protección y su reemplazo por otros árboles igualmente protectores, pero de mayor utilidad es deseable. De primera intención se creyó que la palma era una especie agresiva de crecimiento rápido que invadía los claros causados por huracanes. Una serie de estudios sobre el crecimiento de palmas analizadas en informes anuales anteriores han demostrado que esto es falso; su crecimiento en todas partes es lento, fluctuando entre 4 y 10 pulgadas por año.

La escasez de árboles de otras especies entre las palmas ha creado alguna duda en cuanto a que si éstos crecerían bien en palmares. Estos palmares son de suelos inestables tales como iberas o despeñaderos. Parece que otros árboles se caen antes de madurar por falta de agarre. Los estudios sobre el crecimiento de palmas y los métodos para computarlo a base de la condición de éstas o su medio se ha llevado a cabo porque el promedio relativo de crecimiento de las palmas pudiera indicar dónde dentro del palmar podría la introducción de mejores especies ser más prometedora. Los estudios informados hace un año indicaron el más rápido crecimiento de las palmas intermedias y dominadas al comparárseles con las dominantes y codominantes, aparentemente cuestión de edad. También se descubrió un método para calcular la edad de las palmas según la distancia vertical entre las señales dejadas en el tronco por las hojas adyacentes.

Un estudio del crecimiento de 5 años de 357 palmas del Bosque de Luquillo proporcionaron este año más información sobre esta especie. La relación entre el diámetro a la altura del pecho y el promedio de altura puede verse en la Tabla 5 que está basada en una curva sobre datos de crecimiento de 5 años. El cambio en el ritmo de crecimiento con diámetro se pronuncia más después del intervalo de 6 pulgadas. Deberá entenderse al interpretar esta tabla que la relación entre diámetro y edad tiende a ser inversa. Las palmas jóvenes y vigorosas tienen generalmente un diámetro mayor que el de las más viejas. Puede llegarse a la conclusión de que mientras mayor el promedio de diámetro, en paridad de condiciones, tanto mejor el ambiente estacional para palmas (posiblemente para otros árboles también).

Tabla 5.—**El crecimiento de la palma de sierra con relación al diámetro**

Diámetro a la altura del pecho	Promedio anual de altura
Pulgadas	Pulgadas
3	1,1
4	2,7
5	4,5
6	5,9
7	6,7
8	7,3
9	7,8
10	8,9

La relación entre la altura inicial del árbol y el promedio anual de crecimiento durante los siguientes 5 años queda señalada en la Tabla 6. Estos datos muestran una relación generalmente inversa entre la altura y el crecimiento. Esto comprueba el hecho de que los árboles jóvenes crecen más rápidamente.

Tabla 6.—**Crecimiento de la palma de sierra con relación a la altura**

Altura inicial	Promedio anual de altura
Pies	Pulgadas
5	6,4
10	7,1
20	7,1
30	6,1
40	4,6
50	3,0

Contribución Actual y Potencial de los Bosques

La casuarina alcanza 16 pulgadas de diámetro en 20 años en los arenales costaneros

La casuarina (*C. equisetifolia* Forst), oriunda de Australia ha sido por muchos años el árbol favorito de Puerto Rico para siembras en fincas. Se adapta a suelos pobres, crece rápidamente, su tronco recto se presta para muchos usos en la finca y es de aspecto atractivo. Su madera no es fácil de trabajar, ni, en la mayor parte de ambientes estacionales, adquiere un diámetro suficientemente grande para madera aserrada.

Una de las primeras plantaciones de esta especie en Puerto Rico la estableció en 1922 la Central Fajardo en la Hacienda Monserrate cerca del pueblo de Luquillo. Esta plantación, de cerca de 4 acres, contenía 2.700 árboles espaciados de 8 x 8 pies. Este sitio se consideraba sin valor para otros propósitos. El suelo de arena blanca casi estéril, el límite de saturación de agua era alto y ninguna otra cosecha se daba allí debido a los cangrejos.

Esta plantación resultó ser de crecimiento extraordinario y demostró la adaptabilidad de esta especie a los arenales costaneros abrigados. A principios de 1932, 10 años después, el suelo exterior había tomado un color pardo oscuro y estaba alfombrado de agujas. Quedaban pocos cangrejos y una vegetación herbácea se había desarrollado bajo los árboles. En aquella época el rodal contenía un volumen de 2.750 pies cúbicos por acre, casi todo apropiado para postes y espeques. Más tarde ese mismo año un huracán arrancó o partió todos menos 25 de los árboles.

Una segunda plantación se estabeció en el mismo lugar en 1932. A los 10 años una medición de 559 árboles arrojó una escala diametral de 4 a 18 pulgadas, con un promedio de 9,5 pulgadas. El dosel tenía 85 pies de alto y uno de los árboles medía 105 pies. A los 17 años el número de árboles había bajado a 206 debido a la eliminación gradual de los árboles más débiles. El diámetro promedio de los que quedaron era de 14,4 pulgadas.

La medición de los 20 años se hizo este año. Se encontró que aunque el rodal está ahora completamente abierto, muchos de los árboles están perdiendo vigor. Se han cortado más árboles y sólo quedan 181. Estos que indudablemente son de los primeros árboles dominantes y codominantes tienen ahora una escala diametral de 8 a 25 pulgadas con un promedio de 16,2 pulgadas.

En Puerto Rico no se ha aprovechado el beneficio de este crecimiento rápido de la casuarina. Aunque la madera no es de alta calidad para construcción, experimentos han demostrado que se le pueda tratar con éxito, con preservativos que prolongarán su utilidad a por lo menos 10 años como espeque o poste en tierra. Los espeques que no han sido tratados duran muy poco, los postes más

grandes pueden durar hasta 5 años pero la mayoría no dura 24 meses.

Plantaciones de casuarina en la Isla de La Mona se deterioran

Durante los años de 1937 a 1939 se plantaron en árboles cerca de 400 acres en los llanos costaneros de la isla de La Mona situada entre Puerto Rico y La Española. Esta área recibe como 40 pulgadas de precipitación anualmente y los terrenos sembrados son mayormente arenas de playa con una profundidad de 6 a 30 pulgadas. Las principales especies sembradas fueron casuarina (*C. equisetifolia* Forst) y caoba antillana (*Swietenia mahagoni* Jacq.). Aunque esta zona ya no es reserva forestal pública, la isla está casi deshabitada y las plantaciones no han sido tocadas. Porque estas plantaciones indican lo que podría esperarse de plantaciones en sitios similares en Puerto Rico, su desarrollo ha sido seguido de exámenes y mediciones periódicas.

La casuarina ha probado ser la especie sobresaliente. Posiblemente debido al clima más seco no ha crecido tan rápidamente como en la Hacienda Monserrate (ya descrita en este informe) pero los árboles generalmente tienen buena forma y han producido rodales cerrados. Su diámetro a los 15 años fluctúa entre 4 y 12 pulgadas y la altura entre 30 y 100 pies.

El desarrollo de este árbol está íntimamente relacionado con el grado de protección contra el viento y la calidad del suelo. En una ensenada protegida, con suelo relativamente profundo, los árboles tienen un promedio de 7,5 pulgadas de diámetro y de 80 a 100 pies de altura. En una punta arenosa y descubierta de las cercanías, los árboles tienen solamente la mitad de este tamaño, el dosel está más abierto, el follaje escaso y algunos tienen las copas muertas que estan siendo reemplazadas por ramas desarrolladas de brotes en reposo en las partes bajas de los troncos. La apariencia enfermiza de estos árboles se ha desarrollado últimamente. Parece haber poca perspectiva de crecimiento adicional. La causa parece ser el efecto combinado de exposición al viento y del casi estéril suelo arenoso sobre aguas salobres.

Aunque los árboles de estas plantaciones se están deteriorando poco a poco, probablemente continuarán ofreciendo sombra halagadora a lo largo de la playa por muchos años. Sin embargo, mayor rendimiento económico podría resultar convirtiendo estas áreas expuestas en cocales, usando la casuarina como cosecha tutora para las palmas jóvenes.

La caoba tampoco ha tenido éxito en los arenales más descubiertos pero está creciendo bien donde está protegida. En las áreas mejores, árboles dominantes de 15 años tienen de 5 a 7 pulgadas de diámetro y hasta 40 pies de altura. Donde están estrechamente sembrados su forma es buena. La regeneración natural abunda en áreas abrigadas.

Para Aumentar la Productividad de Bosques

Estudios sobre mejora forestal sirven de guía en ordenación

Los estudios de bosques vírgenes han sido de gran valor pues señalan las relaciones selvosas en el relativamente estable medio climático. Estudios similares en bosques que han sido mejorados con la reducción de la densidad del rodal al eliminar árboles extramaduros y de calidad inferior dejan ver más claramente cuales son las mejores prácticas selviculturales. Esto quedó altamente demostrado con los hallazgos en cuatro cuarteles de ½ acre cada uno de los tipos tabonuco y colorado de las montañas de Luquillo que se midieron el año pasado después de 5 años de establecidos.

Estos cuarteles se mejoraron con una corta parcial en 1947. Los rodales restantes para esa fecha se describen en la Tabla 7. Se removió casi todo el rodal de más de 20 pulgadas de diámetro y el área basimétrica se

redujo a casi el 50 por ciento de la que generalmente tienen los bosques vírgenes. La corta extrajo o liberó por lo menos la mitad de los árboles que habían estado dominados, dejando en pie un número mucho más reducido de árboles de esta clase no productiva.

El crecimiento de estos cuarteles queda indicado en la Tabla 8. Se observa un marcado contraste entre los dos tipos, el crecimiento diametral del tipo tabonuco aumentó en un 50 por ciento, en la del colorado no hubo cambio. Un total de 204 árboles de ese tipo, más de la mitad de los que había en los cuarteles, tuvieron un aumento diametral insignificante durante los 5 años. Aun los árboles dominantes, codominantes e intermedios están creciendo lentamente. Arboles de especies de crecimiento rápido como el roble de sierra (*Tabebuia rígida* Urban) en estas clases crecían a razón de sólo 7 pulgadas por siglo. Estos resultados confirman los indicados en la Tabla 4. Puede que ésto se deba a la edad avanzada de muchos de estos árboles como se indica en la Tabla 2.

Tabla 7.—**Rodal remanente por acre en cuarteles mejorados Bosque de Luquillo, 1947**

Indice	Tipo tabonuco		Tipo colorado	
	Cuartel 1	Cuartel 2	Cuartel 1	Cuartel 2
Número de árboles según clase diamétrica				
2 - 6"	726	938	746	682
7 - 12"	58	42	60	68
13 - 20"	20	2	12	18
20" +		2	2	
Total	804	984	820	768
Area basimétrica total, pie cuadrado	91	68	98	100
Por cientos de árboles dominados	38	27	24	27
Volumen total, pies cúbicos	1708	1186	1368	1456

Tabla 8.—**Crecimiento en cuarteles mejorados de Luquillo, 1947-52**

Indice	Tipo tabonuco		Tipo colorado	
	Cuartel 1	Cuartel 2	Cuartel 1	Cuartel 2
Arboles nuevos, por acre	298	220		52
Crecimiento diametral anual medio — todos los árboles, pulgadas	0,103	0,14	0,03	0,05
Crecimiento diametral anual medio, árboles dominantes y codominantes, pulgadas	0,20	0,26	0,05	0,05
Incremento basimétrico por acre a los 5 años, pies cuadrados	30	34	—5	5
Incremento bruto por acre a los 5 años, pies cúbicos	600	595	98	115
Mortalidad a los 5 años, pies cúbicos	85	15	68	60
Incremento neto a los 5 años pies cúbicos	515	580	30	55

Ordenación continuada, eliminando gradualmente los árboles viejos podría crear eventualmente un rodal más productivo. Sin embargo, en los últimos 5 años se ha registrado poco desarrollo de copa, la mortalidad ha continuado alta y por consiguiente una corta secundaria, si hecha muy temprano abriría demasiado el rodal. Además casi no hay arbolitos jóvenes de manera que el reemplazo del rodal viejo por uno nuevo sería aparentemente un procedimiento muy lento. Una solución más prometedora parece ser la introducción de otras especies.

En el tipo tabonuco la corta produjo un marcado vigor en el sotobosque. (Véase ilus. 3). La densidad del rodal aumentó rápidamente hacia su área basimétrica inicial. El crecimiento de copa también fué rápido y pronto cerró el dosel. En consecuencia se hizo, en 1952 una nueva corta en el cuartel No. 1 reduciendo el número de árboles de 1.072 por care a 848 y el área basimétrica de 120 a 105 pies cuadrados por acre. En el cuartel No. 2 se redujeron los árboles de 1.178 a 978 por acre y el área basimétrica de 102 a 89 pies cuadrados por acre.

Perece haber indicaciones de que la corta algo mayor que se hizo en el cuartel No. 2 el año pasado fuera más beneficiosa que la que se hizo en el cuartel No. 1. El crecimiento diametral y el incremento neto fueron más altos en este cuartel. Para evidencia concreta sería necesario una investigación por separado. Quedó demostrado que la corta mayor que se hizo en el cuartel No. 2 no causó una seria invasión de trepadoras.

La caoba hondureña responde bien a la siembra directa, subplantación y corta

El éxito obtenido con la caoba antillana (*Swietenia mahagoni* Jacq.) en siembra directa en los montes calizos de la Estación Experimental de Cambalache (al nivel del mar; precipitación de 55 pulgadas), y el buen crecimiento de la caoba hondureña (*Swietenia macrophylla*, King) en el mismo sitio condujo a pruebas de siembra directa con esta última especie de crecimiento rápido. La ventaja de esta práctica en el caso de la caoba antillana fué que el trasplante a macetas (la única alternativa) se hizo innecesario y por consiguiente la siembra resultó más barata. La siembra directa fué también más fácil porque no había que localizar los bolsillos de suelo profundo donde sembrar arbolitos. El crecimiento temprano de semillones en el bosque ha sido rápido. Este método ha tenido éxito solamente bajo sombra parcial, y ha fracasado debido a sequías en la costa sur (nivel del mar; precipitación, 30 pulgadas).

A fines de 1950 se hizo un sembrado en el bosque Cambalache, echando cuatro semillas en cada punto bajo dosel abierto de 20 pies de altura; éste fracasó debido a germinación escasa. Se volvió a sembrar en 1951 y esta vez fué un gran logro. Para fines del 1952 después que los arbolitos habían sufrido una estación de seca, casi todos los puntos contenían arbolitos vivos de 12 a 18 pulgadas de altura. El desarrollo de los pocos árboles que quedaban de la siembra anterior demuestra que éstos pueden alcanzar altura rápidamente si se les provee de luz de arriba.

En las montañas húmedas, la siembra de semillones de caoba hondureña parece más satisfactoria que la siembra directa (aunque no se ha experimentado con esta última) porque el producto de viveros crece más rápido y temprano y por eso puede competir ventajosamente con la densa vegetación natural. Como en la costa, la subplantación parece ser un método más seguro que la siembra de campo con esta especie.

En 1950 unos 40 acres de bosques hidrofíticos secundarios del Bosque de Luquillo (elevación, 1.000 pies; precipitación, 120 pulgadas) se subplantaron en caoba hondureña. Se despejó el dosel para media sombra y los árboles se espaciaron de 15 a 20 pies bajo los claros. Debido al tiempo sumamente lluvioso solamente sobrevivió el 60 por ciento y fué necesario sembrar de nuevo. A los 18 meses los árboles tenían un promedio de 5

pies de altura y estaban bien vigorosos. No había señales de daños causados por el insecto taladrador (*Hypsipyla grandella*). Es evidente que no todo el cuido del plantío puede abandonarse porque se siembra bajo dosel. La necesidad del desyerbo queda casi eliminada pero hay que quitar las trepadoras una o dos veces, y para mantener el dosel abierto sobre los árboles, habrá que atenderlo cada 24 meses durante los primeros años.El resultado de esta prueba y la evidencia obtenida con siembras de campo anteriores, han servido de base para la subplantación de 800 acres de bosques hidrofíticos secundarios en los sitios más abrigados del Bosque de Luquillo.

Evidencia de las potencialidades de la caoba hondureña en zonas de bosques hidrofíticos se ha obtenido mayormente de un plantío pequeño hecho en 1931. Este plantío, de unos 4 acres, se dejó desarrollar sin cuidos selviculturales. A los 20 años el área basimétrica era de 140 pies cuadrados por acre, y el rodal era tan denso y uniforme que el 80 por ciento de los árboles estaban en la clase de copa intermedia. Las copas son opacas y de un verde más obscuro que lo regular en plantíos jóvenes. Los diámetros fluctúan entre 4 y 15 pulgadas, siendo el promedio 9,6 pulgadas. El incremento medio anual del área basimétrica por árbol para los primeros 17 años fué 0,0238 pies cuadrados; para los últimos 3 años fué 0,0342 pies cuadrados, lo que indica un crecimiento continuo y rápido. Muchos de los árboles estaban ahorquillados pero una corta este año los eliminó totalmente. Esta corta a los 20 años rindió 1.000 pies cúbicos de madera de aserraje por acre con lo que se sufragaron los gastos de siembra (sin réditos). La salud, tamaño y ritmo de crecimiento de estos árboles indican que esta especie es la más prometedora para sitios protegidos dentro de la zona de bosques higrofíticos.

Un estudio de aclareos más oportunos en el Bosque Río Abajo (elevación, 500 pies; precipitación, 80 pulgadas) está sirviendo de guía para ensayar en más de 500 acres de plantíos jóvenes de esta especie por toda la isla. En 1950 se hicieron pruebas en un plantío de 13 años enclavado en una hondonada caliza abrigada. Este plantío (210 árboles dominantes y codominantes) había alcanzado un diámetro medio de 6,2 pulgadas, un dosel de 50 pies y un área basimétrica de 80 a 110 pies cuadrados por acre. El crecimiento basimétrico promedio anual para los primeros 13 años fué de 0,0161 pies cuadrados. El crecimiento basimétrico anual corriente por árbol para los dos últimos años en rodales sin aclareos fué de 0,0151 pies cuadrados, un pequeño descenso.

De dos cuarteles de ½ acre cada uno en este rodal se cortaron 320 árboles por acre dejando unos 400. El área basimétrica restante fluctuaba entre 56 y 76 pies cuadrados por acre. El aclareo eliminó los árboles de forma indeseable sin tomar en consideración el tamaño, los dominados y los intermedios. El claro aumentó de 1/3 a 2/3 la proporción de todos los árboles en las clases copa, dominantes y codominantes, y aún a los árboles que ya estaban en estas clasificaciones se les dió más espacio. (Véase ilus. 4).

Un reexamen de estos plantíos aclareados ofreció algunos de los resultados previos. El claro no era lo suficientemente grande para ocasionar problemas con las trepadoras aunque las pocas que se encontraron en las áreas más abiertas indican que ésto hubiera sido el resultado de ser mayor el aclareo. Casi ninguno de los árboles se doblegó con el viento al ser liberado. El crecimiento de retoños en los troncos de los árboles cortados hace 2 años no tuvo mayor importancia. El crecimiento diametral se aceleró con el clareo. El crecimiento diametral anual promedio por árbol en estas clases para los 2 años después del clareo fué de 0,48 pulgadas (base, 42 árboles), comparado con 0,44 pulgadas (base, 42 árboles) en los cuarteles adyacentes sin clarear. La diferencia es más notable si todos los árboles restantes (incluso los subordinados) se incluyen en esta comparación: 0,26 pulgada vs. 0,17 pulgadas. Un resultado muy significativo es la creciente

preponderancia de los árboles grandes. Están alcanzando altura rápidamente y por lo menos 50 de ellos por acre sobresalen del dosel. Estos son sin duda árboles de cosecha final. Otro aclareo para acelerar el crecimiento no será necesario hasta que las copas de estos árboles grandes no se unan, ésto es, de 5 a 10 años después del clareo de 1950. Al cabo de 5 años puede que sea conveniente aclarar de abajo apara aprovechar el material comerciable que proporcionen los árboles decadentes.

El mangle de 20 años responde prontamente al aclareo y a la corta de diseminación

Hay más de 15,000 acres de bosques de esteros dominados por el mangle (*Laguncularia racemosa* (L.) Gaertn) en las márgenes de estuarios, lagunas y bahías protegidas de Puerto Rico. Como estos bosques accesibles han sido despojados constantemente desde tiempos remotos ya no quedan árboles grandes, pero como la regeneración es rápida estas áreas están todavía cubiertas de bosques jóvenes. Suelos poco propicios evitan la invasión por otras especies quedando el mangle casi puro. (Véase ilus. 5).

Pero a pesar de las aparentes condiciones favorables el crecimiento del mangle no es del todo satisfactorio. La corta total, el procedimiento regular, ha dado por resultado rodales de arbolitos que se estancan. Estudios han probado que hasta 19.000 renuevos por acre pueden desarrollar un diámetro de una pulgada o más. Entonces, como ningún árbol sobrepasa pronto a los que lo rodean, el crecimiento tiene que esperar la lenta eliminación de miles de árboles a menudo llevada a cabo por insectos taladradores. En un estudio de 223 árboles de una pulgada se encontró que el crecimiento diametral medio era de 0,6 en 11 años. Como los árboles son demasiado pequeños para la utilización y su aclareo es caro, este estancamiento es obstáculo para la alta productividad de este tipo de bosque.

Se está experimentando con dos métodos para reducir la densidad en estos rodales. El primero, la corta parcial para crear un bosque de edades múltiples. Pero había que encarar la aparente intolerancia de la especie y el peligro de derribo por el viento. El segundo método, la corta total en fajas perpendiculares a los vientos prevalecientes, moviéndose hacia barlovento y cortando otra faja tan pronto se obtenga la regeneración de la anterior. Los peligros aquí son el derribo por el viento y el temor de que una faja, bastante ancha para asegurar la regeneración, pueda también producir un rodal joven demasiado denso.

El rodal seleccionado para estas pruebas en el Bosque de Aguirre se desarrolló después de una corta total en 1930. El diámetro promedio de los árboles dominantes y codominantes es de 8 pulgadas y el área basimétrica de 110 a 140 pies cuadrados por acre. El dosel tiene unos 60 pies. Cuatro cuarteles de ¼ de acre cada uno se establecieron en 1949 para determinar el ritmo de crecimiento en el rodal antes de hacer cambio alguno. Se encontró que durante los últimos 3 años el crecimiento diametral promedio fué de 11,6 al año (0,20 pulgadas para los dominantes y codominantes solamente), que al año se moría un promedio de 95 árboles por acre y que no había cambio en el área basimétrica o volumen.

En dos de los cuarteles (excluídos del análisis anterior) una tormenta tumbó 82 árboles en 1952, ocasionando claros en el dosel. Después de la tormenta se volvió a medir y clasificar los árboles adyacentes al claro con relación a la posición de las copas. El análisis del crecimiento de 104 de estos árboles aparecen en la Tabla 9. Los crecimientos para la comparación son los de 1949-50, antes de la tormenta, y 1950-52 después de ésta. Las últimas dos líneas de la Tabla 9 indican que es posible la aceleración inmediata del crecimiento de árboles dominados en este rodal al ser liberados, aunque hayan estado dominados por 20 años.

Tabla 9.—Efectos de liberación sobre crecimiento de manglares

Clase según la copa		Número de árboles	Promedio anual de crecimiento diametral	
Antes de la liberación	Después de la liberación		Antes de la liberación	Después de la liberación
			Pugadas	Pugadas
Codominantes	Dominantes	9	0,23	0.27
Intermedios	Codominantes	38	0,18	0,17
Intermedios	Dominantes	4	0,04	0.40
Dominados	Intermedios	53	0,06	0.17

La tormenta proporcionó conocimientos valiosos sobre selvicultura. Quedó demostrado que el rodal responde a la liberación y que son los árboles más grandes los que caen; por consiguiente éstos se deben cosechar, la corta es deseable para el incremento. En efecto, se hicieron cortas en dos de los cuarteles; en uno se arrancaron 208 árboles y se redujo el área basimétrica de 129 a 78 pies cuadrados por acre, del otro se sacaron 328 árboles por acre y se redujo el área basimétrica de 108 a 63 pies cuadrados por acre. Estos cuarteles seguirán en observación para determinar futuro crecimiento, derribo por vientos y regeneración.

La corta por fajas se empezó en este rodal en 1951. Una faja de 66 pies de ancho por 660 pies de largo se extendió de norte a sur. De esta madera se hizo carbón. A fin de año se constató que los vientos no habían perjudicado esta faja. El número de tocones que habían retoñado no podían constituir rodal, además sus tallos torcidos no podían dar buenos árboles. Semillones de 4 pulgadas surgieron en abundancia bajo las ramas colgantes de los árboles a lo largo de la orilla este de la faja. Otros semillones surgieron dentro de la faja donde evidentemente era el límite de la marea alta cuando maduraron. Hacia barlovento, extendiéndose 30 pies dentro del bosque, el suelo está cubierto de un denso rodal de semillones que aparentemente pueden soportar sombra de arriba y luz lateral. Será necesario continuar observando hasta ver si la faja tiene el ancho adecuado y cuando puede cortarse otra faja adyacente hacia barlovento.

Resumen de las experiencias con el eucalipto

El eucalipto por su rápido crecimiento en la América del Sur atrajo la atención hace años y muchas especies se introdujeron en Puerto Rico. Para 1940 había algunos árboles en las fincas de la isla y algunos plantíos pequeños en los bosques públicos. Luego se han sembrado más de 2.000 acres de bosques públicos en *E. robusta* Smith y *E. kirtoniana*. F. V. M. Con semillas de otras especies traídas del Brasil y de Guatemala se han preparado plantíos de prueba en distintos medios estacionales. El progreso de estos plantíos se ha analizado períodicamente en informes anuales anteriores. Aquí se resume brevemente la experiencia obtenida hasta la fecha con las especies más importantes.

E. acmenioides Schauer.—Sembrado en distintos ambientes estacionales desde el nivel del mar hasta 3.500 pies de elevación. No promete. Ha fracasado en suelos lateríticos y el crecimiento ha sido errático en otros sitios. En uno de los mejores sitios de suelo suelto, rojo y profundo en el Bosque de Luquillo (elevación, 500 pies sobre el nivel del mar; precipitación 120 pulgadas) algunos ár-

boles de 8 años han alcanzado un diámetro de 7 pulgadas y una altura de 40 a 60 pies. Sin embargo la mayor parte de los árboles son más pequeños y de forma pobre y débil.

E. alba Reinwardt.—Sembrados en una variedad de medios estacionales desde el nivel del mar hasta 3.500 pies de elevación. Es la mejor especie hasta la fecha para elevaciones hasta de 500 pies. En suelos de poca profundidad en el área experimental de St. Just (elevación, 300 pies; precipitación, 70 pulgadas), un plantío de 8 años ha alcanzado entre 40 y 60 pies de altura con árboles de 3 a 5 pulgadas de diámetro. En suelos rojos, sueltos y profundos del Bosque de Luquillo (elevación, 500 pies; precipitación, 120 pulgadas), árboles de 8 años tienen diámetros de 6 a 9 pulgadas y altura de 60 a 75 pies. En terrenos pobres y arcillosos en el Bosque Toro Negro (elevación, 3.500 pies; precipitación, 110 pulgadas), árboles de 7 años tienen una altura promedio de 13 pies con 25 pies de altura máxima. Las copas cónicas y achatadas indican que esta especie no se adapta tan bien a estas alturas como otras especies. En suelos lateríticos pobres del Bosque de Maricao (elevación, 2.000 pies; precipitación, 100 pulgadas), esta especie fracasó.

E. botryoides Smith.—Sembrado en distintos ambientes estacionales hasta 3.500 pies sobre el nivel del mar. Logro mediano en algunos de los mejores sitios, fracaso en el resto. En suelo suelto y profundo del Bosque de Luquillo (elevación, 500 pies; precipitación, 120 pulgadas) árboles de 8 años miden 60 pies. El rodal no es uniforme y muchos de los árboles están achaparrados.

E. citriodora Hook.—Sembrada en variedad de ambientes estacionales desde el nivel del mar hasta 3.500 pies de elevación. Generalmente lenta en crecimiento y de copa escasa en todo sitio. En suelo profundo del Bosque de Luquillo (elevación, 500 pies; precipitación, 120 pulgadas), la gomosis es común y la mayor parte de los árboles se mueren durante los primeros 8 años. En suelos pesados degradados en el Bosque Toro Negro (elevación, 3.500 pies; precipitación, 110 pulgadas) árboles de 7 años tienen una altura media de 10 a 12 pies.

E. corymbosa Smith.—Sembrada en montañas solamente. Supervivencia buena. Arboles lozanos, crecimiento lento. En el Bosque de Toro Negro (elevación, 3.500 pies; precipitación, 110 pulgadas), árboles de 6 años tienen altura media de 15 a 20 pies.

E. globulus Labill.—Sembrado en montañas — no se adapta. Un plantío en el Bosque Toro Negro (elevación, 3.800; precipitación, 120 pulgadas), no se está desarrollando bien. Al cabo de 8 años algunos árboles miden 25 pies. La experiencia ha demostado que esta especie requiere un clima más fresco.

E. kirtoniana F. v. M.—Sembrada en distintos ambientes estacionales, mayormente a 2.000 pies de elevación. Esta especie, anteriormente informada como *E. resinifera* Smith fué identificada el año pasado. Está entre las que se adaptan mejor a Puerto Rico y su rendimiento en altura es posiblemente mayor que el de las otras. Arboles sembrados en el Bosque Toro Negro (elevación, 3.000 pies; precipitación 110 pulgadas), en 13 años han alcanzado diámetros entre 6 y 13 pulgadas y alturas de 75 a 90 pies. Esto en terrenos sueltos de mediana a baja productividad. Los árboles codominantes en este plantío están creciendo a un ritmo de más de una pulgadas de diámetro al año. La forma es excelente.

E. maculata Hook.—Hasta la fecha se ha sembrado en cuatro medios desde 500 hasta 3.500 pies de elevación. En suelos sueltos del Bosque de Luquillo (elevación, 500 pies; precipitación, 120 pulgadas) hay árboles de 8 años que miden de 35 a 40 pies de altura, algunos con diámetro de 3 a 5 pulgadas, siendo este plantío uno de los mejores en este medio. En suelos pobres y arcillosos del Bosque Toro Negro (elevación, 3.500 pies; precipitación, 110 pulgadas), árboles de 7 años tienen un promedio de 22 con un máximo de 25 pies, están lozanos, son uniformes y entre

los mejores de estos suelos pobres. En un suelo laterítico de pobre calidad en el Bosque de Maricao (elevación, 2.000 pies; precipitación, 100 pulgadas) árboles de 5 años tenían altura media de 6 pies con un máximo de 12 pies. *E. maculata* es una de las especies que mejor se adapta especialmente a elevaciones mayores. No desarrolla gomosis ni mortalidad temprana en el grado que los desarrolla *E. citriodora* en los medios estacionales donde se han sembrado ambos.

El pilularis Smith.—Sembrada sólo en las montañas. Crecimiento mediano. En el Bosque Toro Negro (elevación, 3.500 pies; precipitación, 110 pulgadas) la supervivencia fué alta, los árboles están saludables y bien formados, con una altura promedio de 25 pies a los 8 años.

E. propinqua Deane & Mainden.— Se le siembra en distintos ambientes estacionales desde el nivel del mar hasta 3.500 pies de elevación. Requiere mejores suelos que los que se usaron para las pruebas. En el Bosque de Luquillo (elevación, 500 pies; precipitación, 120 pulgadas) sólo algunos árboles se desarrollaron bien en las áreas mejores del plantío. A los 8 años el tamaño máximo es 7 pulgadas de diámetro y 60 pies de altura. En el Bosque de Toro Negro (elevación, 3.500 pies; precipitación 110 pulgadas) pocos árboles en el fondo del valle alcanzaron a 25 pies de altura después de los 7 años.

E. resinifera Smith.—Sembrado en distintos medios estacionales desde el nivel del mar hasta 3.500 pies de elevación. Una de las especies que mejor se adapta a las montañas. En el Bosque Toro Negro (elevación, 3.500 pies; precipitación, 110 pulgadas) árboles de 7 años están lozanos, uniformes y miden de 30 a 35 pies de altura. En el Bosque de Maricao (elevación, 2.000 pies; precipitación, 100 pulgadas) en suelos lateríticos pobres donde 20 especies de eucalipto han fracasado, los árboles tienen una altura media de 20 pies a los 8 años. En la Estación Experimental de Cambalache (nivel del mar; precipitación, 55 pulgadas) los árboles han alcanzado también 20 pies de altura y 4 pulgadas de diámetro en 8 años. Este es un desarrollo mejor que el que regularmente se ha obtenido al nivel del mar con otras especies de eucalipto, pero el crecimiento ha declinado últimamente y parece ser que la especie no se adapta bien aquí.

E. robusta Smith.—Sembrado en distintos medios estacionales hasta 3.800 pies de elevación. Es la especie que más se ha sembrado en Puerto Rico y se adapta bien a suelos pobres particularmente los húmedos y aún a los lateríticos, a elevaciones mayores de 1.500 pies. No se adapta al nivel del mar. En suelos profundos y húmedos de 2.000 pies de elevación los árboles de 13 años fluctúan entre 8 y 16 pulgadas de diámetro y miden hasta 75 pies de altura. No hay señales de decadencia en el crecimiento. (Véase ilus. 6).

E. sideroxylon A. Cunn.—Sembrado solo en las montañas. No se destaca pero es vigoroso y de buena forma. En el Bosque Toro Negro (elevación, 3.500 pies; precipitación, 110 pulgadas) árboles de 7 años tienen una altura media de 30 pies.

E. tereticornis Smith.—Se ha sembrado en toda clase de ambiente estacional desde el nivel del mar hasta 3.500 pies de elevación. Como el *E. alba* y distinto a otros probados esta especie se ha dado mejor en elevaciones bajas. En la Estación Experimental de St. Just (elevación, 300 pies; precipitación, 70 pulgadas) en un suelo bien drenado de arcilla esquitosa los árboles tienen de 3 a 6 pulgadas de diámetro y de 50 a 60 pies de altura. Por el contrario en el Bosque Experimental de Cambalache (nivel del mar; precipitación, 55 pulgadas) árboles de la misma edad en suelos arcillosos no prosperan. Tienen un promedio de 3 pulgadas de diámetro y miden de 35 a 50 pies de altura: sus copas son raras. En el Bosque Río Abajo (elevación, 500 pies; precipitación, 80 pulgadas) los árboles de 8 años fluctúan entre 8 y 25 pies de altura. Esto se debe a un suelo poco fértil y degradado. A elevaciones de 3.500 pies no han tenido crecimiento perceptible y parecen destinados a fracasar.

El reciente mercado para postes de eucalipto y la posibilidad de que pueda utilizarse para la fabricación de cartón para divisiones hacen del eucalipto una producción prometedora para los miles de acres de propiedad particular baldíos y falta de abrigo. A base de este desarrollo se harán nuevas investigaciones sobre la adaptabilidad de distintas especies. Se están introduciendo nuevas especies y se ensayará con las que ya se tienen en mejores ambientes estacionales. También se encaminarán experimentos a descubrir mejor utilización de la madera.

El ciprés mejicano sigue creciendo rápidamente

El ciprés mejicano (*Cupressus lusitanica* Mill.), un conífero de valor nativo de la América Central y de Méjico, se trajo hace 4 años y se ha experimentado con él en varios ambientes estacionales especialmente a niveles altos. Parece ser uno de los árboles más sobresalientes que se hayan introducido.

Un plantío de 4 años en el Bosque de Luquillo (elevación, 1.800 pies; precipitación, 140 pulgadas) en suelo profundo pero pantanoso ha alcanzado una altura de 12 pies. En el Bosque Toro Negro (elevación, 3.500 pies; precicipitación, 120 pulgadas) un plantío de ciprés de 2½ años en una ladera descubierta de suelo llano y rocoso está más vigoroso que el eucalipto o el roble (*Tabebuia pallida* Miers. La altura media del ciprés es de 7 pies con árboles, hasta de 12 pies. Arboles subplantados bajo las sombras de cafetales abandonados en el Bosque Toro Negro están creciendo bien a pesar de la sombra. En un suelo laterítico pobre en el Bosque de Maricao (elevación, 2.000 pies; precipitación, 100 pulgadas) los árboles empezaron a ganar en altura tan pronto fueron sembrados y son de un color verde brillante que no se ve en ningún otro árbol sembrado en el mismo sitio ni en la vegetación nativa. En este sitio aún el eucalipto parece destinado al fracaso.

Esta especie parece sobresalir en muchos respectos. Con un mínimo de desyerbo, árboles jóvenes pueden competir con la vegetación agresiva como los helechos y la yerba melado (*Melinus minutifolia*). Está creciendo bien bajo gran variedad de condiciones desde el nivel del mar hasta 3.500 pies de elevación en los peores suelos de la Isla. Parece crecer bien tanto bajo sombra como en descubierto. En ritmo de crecimiento temprano supera al de la mayor parte de los árboles sembrados.

Hasta la fecha sólo se ha notado una característica indeseable que no guardaría mayor importancia según se desarrollen los árboles. En algunos sitios los troncos crecen tan ligero que son muy flexibles y el viento los doblega. Esto no ocurre en todas partes, por ejemplo, en Toro Negro ha habido poco daño causado por los vientos.

Los rodales de casuarina ofrecen buen ambiente para la subplantación

La casuarina (*C. equisetifolia* Forst) se siembra extensamente en Puerto Rico para proteger suelos degradados por el cultivo. El árbol crece muy rapidamente en toda la Isla y se adapta a todas las altitudes menores de 1.000 pies. Pero como las hormigas destruyen las semillas no se propaga naturalmente. Por consiguiente si ha de perpetuarse la casuarina habrá que sembrar de nuevo periódicamente a un costo considerable. Si han de seguirle otras cosechas se necesitarán técnicas de conversión que no dejen el sitio expuesto.

Un estudio para la conversión de casuarina a otras cosechas forestales se empezó recientemente por medio de la subplantación de distintos árboles bajo rodales de casuarina. Se pensó que si estas especies se establecían antes de la corta podría proveerse protección continua. al suelo. La primera subplantación se hizo en 1949 en suelo llano en el Area Experimental de St. Just (elevación, 300 pies; precipitación, 70 pulgadas) bajo un rodal de casuarina de 4 años que ofrecía un dosel continuo. Una segunda subplantación se efectuó en 1950 en suelo rojo, profundo y

degradado, bajo un plantío similar del Bosque Río Abajo (elevación, 500 pies; precipitación, 80 pulgadas). En este caso la casuarina iba decayendo parece que debido a pudrición de raíz.

Los resultados obtenidos en St. Just son halagadores. Seis especies están muy lozanas al cabo de 3 años, mucho más de lo que se hubiera podido esperar en descubierto en este sitio. Estas incluyen guaraguao (*Guarea trichilioides* L.) y capó prieto (*Cordia allidora* (R. & P.) Cham.), dos valiosas especies de aserraje común en los bosques naturales. El primero se sabe que es tolerante, ha crecido lentamente como es regular pronto después de la siembra. El capá prieto, un árbol menos tolerante fluctúa entre 4 y 8 pies de altura. Otra especie, capá blanco (*Petitia domingensis* Jacq.) se considera generalmente muy intolerante, fluctúa entre 3 y 7 pies de altura y es algo delgado debido a la sombra. El roble (*Tabebuia pallida* Miers), otro árbol intolerante de 2 a 6 pies de alto, de crecimiento rápido y no muestra efectos de dominación. El árbol de sombra más común para el café, la guaba (*Inga vera* Willd.), tiene un promedio de 5 pies de altura y es muy vi goroso. La caoba hondureña (*Swietenia macrophylla* King), es el más vigoroso de todos los árboles con los cuales se ha ensayado. Fluctúa entre 5 y 8 pies de altura y la nueva vegetación es jugosa y verde oscura como si se le hubiese fertilizado con nitrógeno. (Véase ilus. 7). Los semillones de casuarina subplantados para este experimento se están muriendo, parece que por falta de luz.

Los resultados hasta la fecha indican que la sombra de la casuarina no es suficiente para evitar el rápido desarrollo de otras especies en el estrato inferior. El vigor y buen color de los árboles subplantados no comprueban la creencia general de que la casuarina, debido a que crece rápidamente en sitios pobres, agota el suelo. El buen desarrollo de la sombra para el café, la guaba, hace necesaria la investigación en relación con la conversión de rodales de casuarina en cafetales. Arbustos de café sembrados a la sombra de la casuarina en Río Abajo están creciendo bien.

Dos herbicidas resultan efectivos para antes de la emersión

El desyerbo en los viveros forestales constituye uno de los mayores gastos de producción. El uso de herbicidas ha reducido estos gastos en muchos sitios, y algunos experimentos se han emprendido aquí en Puerto Rico para determinar la conveniencia de herbicidas a este propósito. Hace un año se informó que la aplicación de una mezcla de tricloro-acetato de sodio a razón de 50 libras por acre y 2,4-D (sales amínicas) 8 libras por acre había dominado las hierbas en el vivero de Toa por 8 semanas y que el trasplante de semillones de casuarina o la siembra de semillas de caoba podía hacerse sin peligro 2 semanas después del tratamiento.

El tratamiento antes de la siembra es ventajoso y eficaz. Sin embargo en la esperanza de que se pudiera lograr el mismo resultado usando los herbicidas después de la siembra (y así economizar el tiempo de espera entre el tratamiento y la siembra) se hicieron algunas pruebas con tratamientos pre-emersión este año. Se usaron tres herbicidas: TCA, pentaclorofenolato de sodio (Santobrite) y "matona 30-2-2" (un dinitro matayerba en solución simple). Se usó tricloro acetato de sodio a razón de 20, 50 y 100 libras por acre, y pentaclorofenolato de sodio a razón de 15 y 30 libras por acre y Matona a razón de 6 galones por acre. La especie bajo tratamiento era la caoba hondureña (*Swietenia macrophylla* King). Para determinar la tolerancia de los semillones se les aplicaron los herbicidas después de la primera, segunda y tercera semana de sembrados. (Los arbolitos de caoba brotan generalmente como a las 3 semanas de sembrados).

Veinte libras de tricloro acetato de sodio por acre resultó eficaz como herbicida, especialmente contra las gramíneas. Cuando se aplicó a más de una semana después de la siembra o en aplicaciones mayores de 50

libras por acre resultó perjudicial. La aplicación a razón de 20 libras por acre conservó las eras lo suficientemente limpias por 8 semanas (no más del 35 por ciento se cubrió de hierbajos).

El pentaclorofenolato de sodio usado en cualquiera de las dos formas resultó ser efectivo y sin peligro cuando se usó una semana después de la siembra; usado más tarde no hizo daño a los semilleros pero tampoco dominó los hierbajos que para entonces ya habían germinado. Usando 15 libras por acre una semana después de la siembra se conservaron los lechos lo suficientemente limpios por 8 semanas. Matona en la solución usada no mató las hierbas.

Los mejores tratamientos para antes del brote con TCA y con pentaclorofenolato de sodio aplicados este año son superiores a los recomendados el año pasado para antes de la siembra porque eliminan la espera entre la aplicación y la siembra. Además estos son eficaces hasta 8 semanas en vez de 6 después de la siembra. También se encontró que la aplicación de TCA a razón de 20 libras por acre es tan efectiva como la de 50 libras (la más floja del año pasado).

Deben hacerse más pruebas con éstos y otros herbicidas para aplicarse antes del brote. Luego se harán pruebas con herbicidas para aplicarse después del brote. Este tipo de tratamiento que podría resultar conveniente en cualquier momento después de nacidos los arbolitos sería mucho más satisfactorio que cualquiera de los ya descritos (estos no eliminan el desyerbo final), pero la perspectiva de encontrar tal herbicida parece estar algo remota.

Empieza la investigación sobre la sombra para cafetales

Informes recientes señalan lo aconsejable de perpetuar la decadente industria del café. Los cafetales ofrecen abrigo a casi el 10 por ciento de la superficie de los terrenos de la isla, las áreas más escarpadas y más erosivas. La corta de cafetales, que se ha producido en gran escala durante los últimos 10 años ha traído un breve ciclo de cosechas de cultivos que degenera el suelo y termina por convertirlo en yerbaje o breñal.

Hace un año se hizo un examen del rendimiento del café conjuntamente con el Negociado de Industria Vegetal para orientar investigaciones en este campo que pudieran ayudar a los cafeteros. Varias fases importantes de la selvicultura merecen investigación. Este año se empezó un estudio de los actuales y potenciales árboles de sombra. El Negociado de Industria Vegetal ha comenzado un estudio formal de producción de cafetales sin sombra.

Los árboles de sombra más comunes en los cafetales son la guaba (*Inga vera* Willd) y el guamá (*Inga laurina* Sw.). La primera parece ser exótica; la última nativa. La guaba es generalmente superior al guamá porque es más frondosa. Los dos árboles sufren de insectos y enfermedades que no solamente minan su vida sino que afectan el cafeto adversamente. En la creencia de que algunas de las muchas *Ingas* oriundas de otros países pudieran resultar mejores para sombra de cafetales el Departamento de Agricultura y Trabajo de Puerto Rico introdujo un número de especies traídas de Venezuela en 1929 y 1930.

La mayor parte de los plantíos hechos con ellas han desaparecido y hay poca información en cuanto a su desarrollo. La especie más sobresaliente, el guamá venezolano (*Inga speciosissima* Pittier) se ha hecho popular como sombra para café y cada año cientos de miles de semillas son diseminadas por el Servicio Forestal y distribuídas a los agricultores. Algunos de los árboles originales que aún quedan en Utuado (elevación, 400 pies; precipitación, 80 pulgadas) al cabo de 23 años tienen un diámetro de 10 pulgadas y 30 pies de altura, es frondosa y de sombra más densa que la guaba y el guamá. Esta especie es fácil de propagar, de supervivencia alta después de sembrada y casi libre de insectos y enfermedades. En la región cafetera (elevación, 1.500 a 2.000 pies; precipitación, 90 a 100 pulgadas) esta especie crece

muy rápidamente. Los árboles de 3 años tienen un promedio de 2 pulgadas de diámetro y de 10 a 15 pies de altura. Los de 6 años tienen un promedio de 3 a 5 pulgadas de diámetro y de 15 a 18 pies de altura.

Otras especies menos conocidas introducidas para la misma fecha incluyen *I. fastuosa* (Jacq.) Willd., *I. spuria* Humb. & Bonpl., y una no identificada pero probablemente es *I. punctata* Willd. Las primeras dos de estas especies han alcanzado 50 pies de altura en 23 años y tienen mejor forma para sombra que *I. speciosissima*. Arboles de *I. fastuosa* de 13 años en sitio abrigado de suelo profundo (elevación, 1.500 pies; precipitación, 90 pulgadas) han alcanzado 10 pulgadas de diámetro, 35 pies de altura y están muy vigorosos.

Una colección de pequeños plantíos de estas especies diferentes se ha organizado en el criadero de La Catalina en el Bosque de Luquillo para obtener semilla para pruebas adicionales. Los semillones de *I. spuria* aparentemente una de las mejores de las introducidas, (se ha usado poco) se distribuyeron a cinco agricultores cooperadores para pruebas en la región cafetera.

Las pruebas preliminares, descritas en otro sitio de este informe, se iniciaron con la casuarina como planta tutora para los árboles de sombra para cafetales. Hay indicaciones de que la sombra de la casuarina es bastante abierta para el rápido desarrollo de la guaba sembrada bajo ella. También se están haciendo pruebas con la caoba hondureña (*Swietenia macrophylla* King) para sombra de café. La copa de la caoba es tan densa que la siembra espaciada o la poda frecuente y el clareo serán sin duda necesarios. Esta primera prueba iniciada en el Area Experimental de St. Just (elevación, 300 pies; precipitación, 70 pulgadas) se hará también en otras fincas de la región cafetera. Estudios futuros incluirán también el eucalipto como árbol de sombra para cafetales.

Bosque joven en terrenos calizos cierra pronto después de la corta de mejora

Los montes calizos del norte de la isla comprenden más del 10 por ciento de la superficie de la isla. Están casi completamente cubiertos de bosques secundarios que se han cortado tantas veces que ya no quedan más que árboles pequeños. Aunque especies buenas no nativas como la caoba antillana crecen allí, el suelo es tan llano que un rodal denso de madera aserrable nunca se desarrollaría. En muchas estancias el mejoramiento del bosque por medio de cortas parciales con el objetivo de una producción máxima de postes y espeques es la práctica selvicultural más prometedora. Como casi todos estos terrenos son propiedad privada esta mejora tendrá que ser barata y de rendimiento temprano.

Un rodal joven, típico en la ladera occidental de un monte calizo del Bosque Experimental de Cambalache (nivel del mar; precipitación, 55 pulgadas) fué seleccionado en 1950 para la investigación de este problema. Esta área se abrió hasta dejar un 60 por ciento de sombra por medio de la eliminación de los árboles que no servían para postes o espeques por su forma y maderas inferiores. Tupidos grupos de los mejores árboles se clarearon donde fué necesario. La corta rindió un haz (128 pies cúbicos) de leña. 40 espeques para cerca por acre y costó cerca de 4 jornales.

El rodal que quedó contenía 1.160 árboles por acre de 2 o más pulgadas de diámetro, con diámetro promedio de 2,4 pulgadas y un área basal de 39 pies cuadrados por acre. Como el 57 por ciento del área basimétrica contenía especies buenas para postes. Las trepadoras no han sido problema. Al cabo de un año se hizo otra corta ligera para abrir el dosel. Otra corta similar se hizo al final del segundo año. Cada una de éstas dió menos de la mitad del volumen que dió la primera pero produjo leña del tipo que necesita el agricultor. Los 235 árboles dominantes y codominantes por acre tienen ahora un promedio diametral de 3,6 pulgadas y contienen buenos postes. Están aumentando en diámetro a un ritmo de 0,21 pulgadas por año. Futuras cortas debieran rendir tanto o más

volumen de postes como de leña. Para conocer a cabalidad el rendimiento económico de esta área se necesitará hacer un estudio continuo de la misma. En los primeros 2 años sólo unos arbolitos han aparecido bajo el rodal. Muchos son retoños de tocones que quedaron después de la primera corta. La cantidad de la reproducción natural determinará en gran medida el éxito de esta técnica.

El bambú continúa crecimiento rápido en mejores ambientes estacionales

El bambú parece tener grandes potencialidades en Puerto Rico. Numerosas especies que se han adaptado en la isla son de valor en otros sitios como materia prima para una extensa variedad de artículos de mercadeo. La provisión en la Estación de Experimentación Federal de un número de especies útiles hasta ahora sin probar condujo a plantaciones de experimentación en montes por toda la isla.

Los primeros plantíos se hicieron en suelo laterítico de mala calidad en el Bosque Toro Negro (elevación, 3.000 pies; precipitación, 110 pulgadas) en 1945. Tres especies, *Bambusa tulda*, Roxb., *B. tuldoides* Munro, y *B. longispiculata* Gamble ex Brandis se sembraron en un área de 20 acres. Después de un lento comienzo, las plantas de 7 años tienen ahora más de la mitad de sus cañas listas para cosechar. El diámetro de estas cañas varía considerablemente con el ambiente estacional y debiera seguir aumentando con la edad. El *B. tulda* es el más grande, con cañas que miden de 3/4 a 1-1/2 pulgadas en las crestas y de 2 a 3 pulgadas en el fondo de los valles. Este bambú es bueno para muebles.

En una estancia mejor en el Bosque de Luquillo (elevación, 800 pies; precipitación, 120 pulgadas) en un suelo rojo y profundo, plantas de 4 años de *B. tulda y longispiculata* tienen 30 pies de altura. Espaciadas de 10 x 10 pies han matado toda otra vegetación.

En un monte calizo del Bosque Experimental de Cambalache (nivel del mar; precipitación, 55 pulgadas) una subplantación de 5 años fluctúa entre 15 y 30 pies de altura. Las cañas han llegado al nivel de dosel y se están desarrollando rápidamente a pesar de lo llano del suelo.

En sitio mal drenado bajo bosque montano en Luquillo (elevación, 2.500 pies; precipitación, 180 pulgadas) grupos de árboles de 5 años de las cuatro especies *B. tuldoides*, *B. tulda*, *B. longispiculata* y *Dendrocalamus strictus* Nees están raquíticas y cloróticas. Los grupos más altos de *B. tulda* sólo tienen de 10 a 15 pies de altura y las cañas solo miden 1 pulgada de diámetro. *Dendrocalamus strictus* sólo mide 6 pies y muchas de las plantas se están muriendo.

El uso de retoños tiernos como material de siembra se ha continuado. Unos 100 renuevos sacados de pimpollos sembrados recientemete se plantaron en el Bosque Cambalache. La supervivencia fué de 90 por ciento. Murieron las plantas que tenían menos raíces y rizomas adheridas.

Los estudios propuestos para el futuro incluyen la fertilización de plantaciones en los montes y la extensión de pruebas en la región caliza del norte.

El cedro macho sobrevive bien al trasplante

El cedro macho (*Hieronyma clusioides* (Tul.) Griseb) un árbol de la región caliza de la costa norte, que produce ua hermosa madera rojo oscuro propia para ebanistería no se ha probado extensamente debido a la irregularidad de la cosecha de semillas y a la dificultad en recolectar, secar y almacenarlas. Ensayos en pequeña escala hechos hace años en el Bosque Río Abajo (elevación, 500 pies; precipitación, 80 pulgadas) demostraron que el ritmo de crecimiento del árbol es moderado pero éste es tolerante y generalmente de forma excelente.

En 1951 hubo una cosecha excepcional y la semilla se secó pronto haciendo posible la producción de 100.000 semillones para mayores ensayos. De éstos se subplantaron 86.000 en el Bosque Guilarte (elevación, 3.000 pies; precipitación, 100 pulgadas) y en

el Bosque Río Abajo donde es nativa esta especie. Subplantaciones de unos 2.000 árboles cada una se hicieron en cinco sitios distintos, incluyendo dos en bosques hidrofíticos en sitios similares a los de las Antillas Menores donde la *H. caribaea* Urb., de la misma familia, es árbol prominente. Se utilizaron pimpollos de 10 a 16 pulgadas de altura y raíz limpia. Hacía buen tiempo. Con excepción del plantío del Bosque Experimental de Cambalache la supervivencia ha sobrepasado el 80 por ciento en todas partes. En Cambalache una sequía intempestiva inmediatamente después de la siembra destruyó el 50 por ciento de los árboles. La mayor parte de los arbolitos que sobrevivieron no parecían afectados por el trasplante y reasumieron el crecimiento prontamente.

El roble dominicano soporta bien el trasplante

El roble dominicano (*Macrocatalpa longissima* (Jacq.) Britton) es una de las especies más importantes de Haití, crece bien en sitios adversos y produce madera buena para construcción y para usos corrientes en las fincas. Es de la familia del roble blanco (*Tabebuia pallida* Miers) de Puerto Rico pero alcanza mayor tamaño. En la creencia de que esta especie pudiera resultar superior para la reforestación de suelos degradados, plantíos de ensayo de 6.000 árboles se hicieron este año en varios ambientes estacionales: en el Bosque de Luquillo (elevación, 800 pies; precipitación, 120 pulgadas); en el Bosque Experimental de Cambalache (nivel del mar; precipitación, 55 pulgadas), en el Bosque Susúa (elevación, 500 pies; precipitación, 50 pulgadas) y en el Bosque de Maricao (elevación 2.000 pies; precipitación, 100 pulgadas).

La supervivencia ha sido más del 90 por ciento en todas las estancias lo que indica que esta especie soporta el trasplante excepcionalmente bien. En los suelos lateríticos de Susúa y de Maricao no prospera. Su mejor desarrollo se produjo en el Bosque de Luquillo donde los árboles ya miden de 4 a 5 pies de altura en las áreas más abrigadas. Esta es una altura mayor que la de otros árboles a la misma edad. Aunque esta especie parece ser más delicada que el roble nativo su desarrollo será objeto de más estudio.

El mago sobresale en crecimiento en la costa norte

El mago (*Hernandia sonora* L.) produce una madera que se usa para maderaje interior en Trinidad y las Antillas Menores. Es nativo de Puerto Rico pero relativamente escaso. Se le ha probado para regeneración de tierras degradadas. Un pequeño plantío del 1944 en el Area Experimental de St. Just. (elevación, 290 pies; precipitación, 70 pulgadas) ha demostrado que esta especie se adapta bien a suelos sueltos llanos en este medio. En 1952, a los 8 años, el diámetro promedio es de 3 pulgadas y la altura un promedio de 30 pies. Los árboles se ven lozanos y en excelente forma. Han limpiado el tronco satisfactoriamente. Se justifican pruebas más extensas en otros ambientes estacionales.

El muérdago menos dañino para la maga que lo previsto

En el informe de 1951 se descubrió un muérdago (*Phthirusa* sp.) que ha atacado numerosas plantaciones jóvenes de maga (*Montezuma speciosissima* (Sessé y Moc.) Dubard) en el Bosque de Guajataca (elevación, 500 pies; precipitación, 70 pulgadas). En 1950 se descubrió que en un área el 80 por ciento de los árboles de un plantío de 13 años de esta valiosa especie de ebanistería se habían contagiado con árboles de capá prieto (*Cordia alliodora* (R. & P.) Cham) de un bosque mixto adyacente. Un plantío en un abra de 14 acres se aclaró y se podó en 1950 para eliminar el muérdago. Al año el muérdago reapareció en la mitad de los árboles y era tan común que se consideró reincidencia. La única solución práctica parecía ser la conversión del plantío a una especie inmune, posiblemente por subplantación.

La investigación de esta área en 1952, un año más tarde, descubrió que el muérdago todavía abunda pero no tan vigoroso como

el año anterior. Una observación minuciosa de árboles marcados demostró que apenas hubo nueva incidencia el segundo año después del tratamiento. Lo que indica que lo que parecía ser otra invasión alarmante del parásito, fué sólo el crecimiento de plantas que no se habían exterminado completamente. Es más, como la plantación está aumentando altura, las ramas inferiores (que sostenían el parásito mejor desarrollado) se están debilitando y muriendo, lo que también matará el parásito. Aun los manojos de muérdago encontrados en los troncos hace un año han desaparecido. Esto pudiera ser un mero reposo, pero el parásito está aparentemente inactivo. Posiblemente el hecho más importante es que los árboles infectados no han sido deformados y están creciendo tan rápidamente como sus vecinos sanos. Esto puede indicar que la maga puede crecer satisfactoriamente a pesar del muérdago. Se harán exámenes para verificar esta conjetura.

El avelluelo se desarrolla rápidamente en la Cordillera Central

El avelluelo (*Colubrina arborescens* (Mill) Sarg.) es madera favorita de postes, nativa de los llanos costaneros mayormente en la sección caliza. Se sembró temprano en varios bosques a elevaciones bajas pero se descartó debido a su crecimiento lento. Lo que pudiera ser una variedad más grande de este árbol se encontró en el interior de la isla y se sembró en el Bosque Guilarte (elevación, 3.000 pies; precipitación, 100 pulgadas) en 1944. Este plantío ha tenido un crecimiento extraordinario y los árboles son de color y forma excelente. Han sobrepasado a todas las especies sembradas menos al eucalipto. En 4 años tenían un promedio de 8 pies de altura y este año, 8 años más tarde, tienen un promedio de 28 pies de altura. Están sembrados en crestas de suelo pobre, lo que indica que esta especie es prometedora para la regeneración de sitios degradados. Se harán más siembras.

La pomarrosa puede controlarse con cortas parciales

La pomarrosa (*Eugenia jambos* L.) una exótica naturalizada es un árbol del estrato inferior en los bosques secundarios en la mayor parte de la región húmeda de Puerto Rico. Es espesa y aunque crece rápidamente bajo condiciones favorables generalmente no produce tallos derechos y se usa principalmente para leña. Da una sombra tan densa que no deja desarrollar los árboles de especies mejores que crecen bajo ella Aunque a veces es de valor para la reforestación de terrenos yermos, en bosques mixtos, es regularmente inferior a los otros árboles y debiera removerse. Responde al aclareo con gran cosecha de retoños lo que indica que resistirá agresivamente los esfuerzos para removerla. Se empezó a estudiar este problema en 1950.

Hace un año se informó que el tamaño del claro del dosel sobre los tocones afectaba el vigor de los mismos para retoñar. Otro examen de los mismos 50 tocones, este año, 2 años después de la corta, demostró que apenas se habían producido renuevos y que el crecimiento en altura de los que se produjeron el primer año no ha tenido importancia desde entonces. Estos halazgos se refieren a tocones solitarios y a los que están entre grupos activos.

La explicación reside en el hecho de que los claros del dosel sobre estos grupos que originalmente medían hasta 10 pies en diámetro, con un promedio de 6 pies, se han casi cerrado como consecuencia del desarrollo de las copas de los árboles adyacentes. Aunque pocos tocones han muerto, no serían problema porque el crecimiento de retoños puede aparentemente arrestarse indefinidamente manteniendo un dosel denso. No parece difícil eliminar la pomarrosa en los bosques mixtos, especialmente si hay reproducción avanzada de especies deseables. Por el contrario la conversión de un rodal puro de pomarrosa requirirá frecuentes cortas hasta que la especie deseada domine.

Selvicultura de la teca ensayada en dos ambientes estacionales

Informes anteriores han indicado que la teca (*Tectona grandis* L) generalmente necesita mejores sitios de los que Puerto Rico puede distraer de la producción de alimento y forraje. Pero en vista del gran valor de la madera de teca, y el hecho de que el progreso de las plantaciones en medios estacionales favorables es espectacular, se le ha sembrado y se está estudiando en sitios que se consideran "demasiado buenos para árboles." Sólo por medio de estudios podrá probarse si la teca puede competir desde el punto de vista económico con otras cosechas.

En el Bosque Experimental de Cambalache (nivel del mar; precipitación, 55 pulgadas) en la costa norte hay extensas vegas entre montes calizos. El suelo profundo de arcilla roja laterítica. En otros tiempos esta área produjo caña de azúcar. En 1950 se sembraron de teca 5 acres. La mitad de esta área se le cedió a los agricultores para intercultivo por 2 años. La otra mitad se mantuvo desyerbada hasta 18 pulgadas alrededor de cada árbol. Al cabo de los 2 años no hay diferencia perceptiva en el desarrollo debido al tipo de cultivo. La teca intercultivada es menos uniformes que la otra, posiblemente a causa de daños a la raíz durante el cultivo. Ambos plantíos tienen un promedio de 12 pies de altura. (Véase ilus. 8).

Una plantación más antigua, también en buen sitio, se encuentra en el Bosque Carite (elevación, 300 pies; precipitación, 80 pulgadas) en suelo aluvial pedregoso. Esta plantación que tiene ahora 16 años tiene un diámetro promedio de 7,4 pulgadas (100 árboles dominantes y codominantes). El crecimiento basal medio por árbol, dominante y codominante, para los primeros 13 años (hasta 1949) fué 0,0219 pies cuadrados. En los tres últimos años ha sido solamente de 0,0059 pies cuadrados, lo que determina que el rodal está muy apiñado. Casi el 40 por ciento de los árboles eran intermedios o dominados y crecían a un ritmo de menos de la mitad del de los dominantes y codominantes. Un cuartel de 1/4 de acre se clareó de 124 a 94 pies cuadrados de área basimétrica por acre con la remoción de 204 árboles por acre. Todos los árboles dominados y como la mitad de los intermedios fueron arrancados. Se harán mediciones más tarde para comprobar el efecto de este aclareo.

La caoba antillana sobrepasa al mesquite en la costa sur

El mesquite (*Prosopis juliflora* DC) se naturalizó en Puerto Rico hace años y ha invadido los bosques en los montes calizos secos de la costa sudoeste. Ahora domina el bosque en un valle dentro del Bosque de Guánica (elevación, 100 pies; precipitación, 30 pulgadas). El hecho de que haya invadido el bosque natural de que retoñe activamente llevó a la conclusión de que era de crecimiento rápido y podía ser fuente altamente productiva de postes y traviesas. Mediciones hechas hace 4 años, demostraron que el crecimiento de este árbol era menos de lo que se esperaba. Se llegó a la conclusión de que la rapidez del crecimiento inicial disminuye temprano, antes de que los árboles hayan alcanzado tamaño de postes.

Al medirse de nuevo este año 24 árboles marcados, dominantes y codominantes, dentro del Bosque de Guánica se obtuvieron datos más confiables en cuanto a su crecimiento. Los resultados de estas mediciones comparados con los obtenidos con la caoba antillana (*Swietenia mahagoni* Jacq.) quedan señalados en la Tabla 10. Esta caoba crece en una plantación de 20 años en otro valle semejante del mismo bosque. Los datos indicados se refieren sólo a árboles dominantes y codominantes. Los dos rodales están cerrados y tienen densidad comparable. Como puede verse el mesquite crece más lentamente que la caoba. Como ésta última rinde productos mucho más valiosos, debiera reemplazar al mesquite, por lo menos en los suelos más profundos donde pueden crecer árboles grandes. No hay propósito de seguir estudiando el mesquite por ahora.

Tabla 10.—Crecimiento del mesquite y de la caoba en Guánica

Especie	Número de árboles	Promedio diametral a la altura del pecho		Promedio crecimiento anual
		Hace 7 años	Ahora	
		Pugadas	Pulgadas	Pugadas
Mesquite	24	4,7	5,6	0.13
Caoba	59	4,1	5,4	0,19

La primavera no crece en región caliza

La primavera (*Tabebuia donnell-smithii* Rose) es una de las maderas más valiosas de Centroamérica. Allí, en la costa oeste, crece rápidamente en buenos sitios, subplantada o en campo abierto. Semillas importadas hace 5 años produjeron algunos árboles que, cuando se sembraron en suelo profundo y bien drenado en el Bosque de Luquillo (elevación, 800 pies; precipitación, 120 pulgadas) crecieron rápidamente, por eso se importaron más semillas el año pasado.

Sembrados para experimentación, de 400 semillones cada uno se levantaron bajo un dosel abierto en el Bosque Experimental de Cambalache (nivel del mar; precipitación, 55 pulgadas) y en el Bosque Río Abajo (elevación, 500 pies; precipitación, 80 pulgadas). En los dos medios estacionales el suelo, aunque fértil es somero, entre 6 y 18 pulgadas de profundidad. Estos árboles no crecieron durante el primer año. Las hojas nuevas son pequeñas, delgadas, cloróticas y parecen atacadas de mosáico. Con pocas excepciones esta condición es universal y no tiene relación con la cantidad de luz recibida. La única aplicación aparente es el suelo; que es menos ácido (pH 6) y menos profundo que aquél donde los árboles están creciendo bien. Se hará un esfuerzo para establecer la deficiencia.

La plantación más vieja en el Bosque de Luquillo mide ahora de 30 a 40 pies de altura y está muy lozana. Los árboles en descubierto tienen un diámetro de 3 a 5 pulgadas. Los árboles en un nuevo plantío en el mismo sitio fluctúan entre 10 y 15 pies de altura al finalizar el primer año.

La palma de sombrero resulta lenta

La palma de sombrero puertorriqueña (*Sabal causiarum* (Cook) Beccari) ha sido base importante para una industria local. La fuente de hojas de palma se redujo grandemente con la separación de un gran área de palmeras para propósitos militares. En un esfuerzo por aumentar la producción se ha estudiado la regeneración artificial de esta palma. El producto de viveros requiere 24 meses. Parte de este producto se sembró en 1946 en el Bosque Experimental de Cambalache (nivel del mar; precipitación, 55 pulgadas en suelo lómico semejante al de su lugar de origen. El crecimiento ha sido muy lento, las palmas alcanzaron de 2 a 5 pies de altura en 6 años. Durante 3 años estuvieron casi inactivas y de un color pobre. A los 5 años se produjeron las primeras hojas utilizables. La primera actividad de esta especie es baja y no justifica mayor estudio por ahora. El Servicio Forestal está distribuyendo algunas palmas para plantíos pequeños en hogares rurales.

Importación de 53 especies de semillas

La necesidad de nuevas y más productivas cosechas forestales ha hecho deseable las pruebas con especies exóticas para determinar su adaptabilidad y productividad en Puerto Rico. La Estación ha hecho pruebas con 120 especies exóticas de árboles durante los últimos 13 años. Durante este año semillas de 53 especies fueron importadas de las regiones tropicales y subtropicales de todo el mundo. Veintisiete de éstas son nuevas en Puerto Rico. Entre las importadas hay 12 gymnosperms y 24 especies de eucalipto. Se determinó el peso de la semilla de 24 especies.

Para Aumentar la Utilidad de la Madera

Los insectos y la podredumbre importantes en el estudio de la post-corta

Hay una creencia arraigada en Puerto Rico (como en otras áreas tropicales) de que

la durabilidad de la madera varía con la época de corta. Algunas de las explicaciones ofrecidas son las fases de la luna, las mareas o las estaciones del año. Aunque las investigaciones no han logrado comprobar que la época de la corta, como tal, afecte en manera alguna la durabilidad de la madera, un estudio del asunto pareció de valor por lo menos para propósitos de demostración. Hace un año la Estación emprendió un estudio de esta naturaleza en que se incluían las siguientes variantes: medio estacional, especie, fases de la luna, estaciones del año, mareas, el tiempo y si los árboles crecían o reposaban. En este experimento se utilizaron 1.800 estacas que se sembraron en los bosques de Toro Negro y Cambalache.

A los 12 meses se hizo una inspección completa para determinar la presencia, naturaleza y grado de deterioro. Se encontró que ninguna de las estacas estaba inservible pero no era posible analizar el efecto de los diferentes tratamientos todavía. Sin embargo agentes de destrucción estaban activos en casi la mitad de las estacas. El daño causado por insectos parecía más importante que la podredumbre. Los insectos más comunes eran pulverizadores y los barrenadores. También había algunos daños causados por termes.

Se ha vuelto a examinar un total de 1.300 estacas al cabo de 18 meses (ésto se hará cada 6 meses). En esta ocasión a cada estaca se le dió un pequeño empuje para determinar si estaba servible. En total se rompieron 75 estacas pero todavía no se nota gran diferencia entre los tratamientos. La debilidad de estos postes ya causada por insectos o por pudrición era mayor a ras de tierra. Sólo algunas estacas se perdieron debido a daños de insectos solamente, pero la mayor parte de los que se perdieron por podredumbre habían sido atacados por insectos. Los túneles hechos por los insectos en la madera fueron sin duda factor importante en el desarrollo de la pudrición.

Exámenes que se hagan más adelante darán más luces en cuanto al deterioro de las estacas y harán posible la comparación de los diferentes tratamientos.

Se determina el peso específico y encogimiento para varias especies

A falta de datos sobre resistencia obtenidos con pruebas reales, el conocimiento del peso específico de diferentes maderas es de valor para calcular aproximadamente algunas de sus propiedades mecánicas y estimar el encogimiento, peso por pie cúbico, volumen vacío y el máximo porcentaje de humedad obtenible y resistencia a la extracción de clavos y tornillos.

Las cifras sobre encogimiento se usan para determinar los cambios de dimensiones con los cambios en contenido de humedad, convirtiendo el peso específico de verde a secado al horno y vice versa.

Durante varios años la Estación ha estado computando el peso específico de varias especies de madera. Este año se ha determinado el peso específico de 11 especies y el encogimiento volumétrico de 7 de éstas. Los datos aparecen en la Tabla 11. Como se ha encontrado en otras partes, el encogimiento volumétrico de estas especies tropicales es generalmente más bajo que el de maderas de densidad comparable de zonas templadas.

Tabla 11.—**Peso específico y encogimiento volumétrico de 11 maderas**

Especies	Peso específico secado al horno basado en volumen		Encogimiento volumétrico de verde a secado al horno basado en dimensiones verdes
	Secado al horno	Verde	
			Porcentaje
Casuarina, *C. equisetifolia* Forst.	—	0,93	
Balsa, *Ochroma pyramidale* Sw. Primera troza			
Durámen	—	0,29	—
Albura	—	0,24	—
Ramas	—	0,18	—
Capá prieto, *Cordia allidora* (R. & P.) Cham	0,49	0,58	15,9
Jácana, *Lucuma multiflora* A. DC.	0,76	0,88	14,2
Aguacatillo *Meliosma herberti* Rolfe	0,44	0,51	14,0
Caimitillo, *Micropholis chrysophylloides* Pierre	0,69	0,78	11,0
Laurel avispillo, *Nectandra coriaceae* (Sw.) Griseb	—	0,59	—
Caimitillo verde, *Micropholis garcinifolia* Pierre	—	0,81	—
Guaraguao, *Guarea trichilioides* L.	0,49	0,57	13,6
Capá blanco, *Petitia domingensis* Jacq.	0,55	0,61	10,2
Mamey, *Mammea americana* L.	0,66	0,76	13,1

Se aplicará mayor esfuerzo a este proyecto durante los próximos años. La falta de equipo para medir el volumen basimétrico ha dificultado este trabajo en el pasado. Esta deficiencia quedará corregida el año próximo.

Los espeques de Eucalipto sin tratamiento duran tres años

El eucalipto (*E. robusta* y *E. kirtoniana* F. v. M.) se ha adaptado tan bien en las montañas del centro de Puerto Rico, que se han emprendido varios estudios para su utilización. Uno de los primeros estudios de esta naturaleza se ocupa de la durabilidad de estas especies como espeque para cercas. Se empezó en 1949. Se enterraron 20 espeques de 4 a 5 pulgadas de diámetro en suelo profundo y bien drenado dentro del Bosque de Guilarte, (elevación, 3.000 pies; precipitación, 110 pulgadas).

Este año (3 años después de instalados) 11 espeques se rompieron bajo empuje moderado y los que resistieron estaban muy débiles. Como los espeques era algo mayores que los que se usan normalmente, puede asegurarse que la duración promedio de los mismos, sin tratamiento no es más de 3 años en este ambiente. La necesidad de tratamiento preservativo es clara y estudios para su desarrollo, ya descrito en este informe, tienen ese fin.

Insectos atacan postes tratados con cloruro de cinc

Las prácticas de preservación de madera en las áreas rurales requieren técnicas simples, aplicables con un mínimo de costo y en pequeña escala. La búsqueda de tales técnicas condujo en 1951 a pruebas del procedimiento a difusión, que puede aplicarse a la madera verde sin descortezar. El preservativo que se probó fué cloruro de cinc con cobre y cromio, que se dice es relativamente resistente a la filtración.

Se hicieron pruebas con tres especies de montañas comunes buenas para postes: eucalipto (*E. robusta* y *E. hirtoniana* F. v. M.) y guaba (*Inga vera* Wild.) Se trataron 16 postes de cada especie. El producto químico se usó al 25 por ciento en solución acuosa. Los postes se dejaron en la solución hasta que hubieron absorbido una libra del compuesto por pie cúbico de madera, un período que varió de 7 a 21 días*. Para determinar la profundidad de la penetración, se rajaron varios postes y se rociaron con partes iguales de una solución al uno por ciento de ferricianuro de potasio, una solución al uno por ciento de yoduro de potasio y una solución al 5 por ciento de almidón soluble. Se encontró que el preservativo se había concentrado en la albura y en las 24 pulgadas más bajas de los postes; éstos se invertieron y se dejaron secar 3 meses antes de colocarlas.

Al cabo de un año todos los postes de eucaliptos tratados con preservativos tienen termes, mientras que los no tratados están sanos. No se nota daños por insectos en ninguno de los postes de guaba tratados o no tratados, pero en uno de los tratados se observa un desarrollo incipiente de hongo.

Aunque son numerosas las notas sobre material tratado con el cloruro de cinc en los Estados Unidos, no se ha encontrado ningún apunte sobre el uso de cloruro de cinc con cobre y cromio, que es un producto relativamente nuevo. La evidencia arrojada por este experimento señala a un desarrollo mayor más favorable en el tratamiento de termes en el eucalipto con cloruro de cinc con cobre y cromio. El ataque de los termes empezó en la corteza y se extendió dentro de la madera. Se harán más pruebas con éste y otros preservativos para averiguar su efectividad en la madera descortezada, y cómo obtener mejor penetración.

Postes de tres especies tratados con creosota sanos a los dos años

La prueba de mayor éxito hecha en la Estación sobre la conservación de postes se llevó a cabo en 1944 cuando varos postes de casuarina (*Casuarina equisetifolia* Forst) fueron tratados con carbolineum por el método de baños fríos y calientes. Estos postes están todavía sanos.

Se decidió aplicar la misma prueba a tres especies comunes: *Eucaliptus robusta* Smith, *E. kirtoniana* F. v. M. y *Micropholis chrysophylloides* Pierre. Se secaron los postes a un contenido de humedad menor del 30 por ciento, se sumergieron entonces en el carbolineum caliente (100ºC) por 4 horas y luego se pusieron a enfriar por 16 horas. La absorción del preservativo varió de 6 a casi 8 libras por pie cúbico. La mitad de los postes se colocaron en el Bosque Toro Negro (elevación, 2,500 pies; precipitación, 110 pulgadas) y la mitad en el Bosque Experimental de Cambalache (nivel del mar; precipitación, 55 pulgadas). Se colocaron testigos de *E. robusta* sin tratar en los dos ambientes estacionales.

Todos los postes que recibieron tratamiento están completamente sanos a los 2 años después de colocados. El preservativo parece estarse filtrando de algunos de los postes. La mitad de los de *E. robusta* han fracasado. Probablemente ninguno de los postes no tratados durará más de un año. Por el contrario, la duración de los postes tratados será seguramente mucho mayor.

Los futuros experimentos de esta naturaleza utilizarán creosota (es más barata que el carbolineum) y se enderezarán al aspecto económico de tales tratamientos.

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* Según el tiempo, siendo menor el período en tiempo seco.

PLANES PARA 1953

Los desarrollos del año pasado señalan la necesidad de mayor esfuerzo en la investigación de prácticas forestales de utilidad para bosques particulares. Esto comprenderá no sólo la repetición de pruebas en esos terrenos, de especies y técnicas que han sido satisfactorias en otras partes, sino también experimentos similares enderezados a abrir mercados de manera que los árboles puedan ser considerados cosecha de turno corto.

Se recomiendan específicamente estudios cooperativos sobre las propiedades para la producción de pulpa con eucalipto, los árboles de sombra para cafetales, y algunas otras especies más comunes. En terrenos particulares se van a hacer extensas pruebas con el eucalipto intercultivado con otras cosechas. Se debiera ensayar con árboles de sombra más productivos en cafetales particulares. También se harán esfuerzos para conseguir una planta para tratamientos a presión para la preservación de vigas, pilotes, traviesas y maderas de construcción domésticas e importadas. También se recomienda una exhibición pública de productos forestales locales, un inventario del consumo y desperdicio de productos forestales usados por industrias locales, métodos de secado, utilidad de la preservación de madera y años de servicio. Para fomentar la dasonomía en terrenos particulares se organizarán áreas de demostración dentro de bosques públicos comparables a los terrenos particulares. Planes para el desarrollo de estas áreas se formularán conjuntamente con el Selvicultor de Extensión y estas áreas se utilizarán principalmente por el Servicio de Extensión. Además se completará el inventario de los plantíos en terrenos particulares empezados hace 2 años y los resultados se incorporarán a un boletín que tratará sobre la siembra de árboles.

El trabajo nuevo propuesto requerirá una reducción de esfuerzos en algunos proyectos viejos. Un número grande de pruebas sobre adaptabilidad se terminará a fines de este año y una revisión del programa de reexámen ha resultado en una economía de tiempo adicional. Un manual que regularice algunos de los procedimientos y técnicas de investigación basado en las experiencias habidas debiera aumentar la eficiencia. Una revisión del análisis de este problema y planes factibles se terminará a principios de año.

The Significance to Puerto Rico of Companhia Paulista Experience with Eucalyptus *

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The Companhia Paulista de Estradas de Ferro, centered at Sao Paulo, Brazil, has carried out what is probably the largest single forestry project yet attempted in Latin America. The results are of great importance not only to the State of Sao Paulo and to Brazil but to all other countries in the tropical and subtropical regions of this hemisphere. It is especially significant that this project has been carried out by private industry, and as such has had to be a success financially as well as technically.

At the turn of this century far-seeing directors of the Companhia became concerned about the increasing scarcity of fuelwood along their railways through the eastern part of the state of Sao Paulo. In 1903 they appointed Edmundo Navarro de Andrade, an agronomist, to establish plantations of trees as a source of fuel for the Companhia.

Navarro began experiments on a property owned by the Companhia at Jundiai, a few miles west of Sao Paulo. He planted 95 different species of trees to determine which gave the highest yield. Eucalyptus from the seed of old trees resulting from early introductions by the Jesuits far ougrew all of the other species and so was subjected to more experimentation and planting. The growth of these plantations so impressed the directors that additional properties were bought along the railway, and in 1909 the center of the work was moved to a larger area at Río Claro.

The interest of the Companhia grew as Navarro's work produced spectacular results. Millions of cruzeiros were invested in the project. Some 17 plantations have now been established along the lines of the Companhia. More than 30,000,000 trees have been planted on some 12,000 hectares. Recognition by the directors of the indirect values and the long-term nature of the project led to investments far in excess of immediate returns. However, present assets in land and plantations and other benefits are adequate to assure total recovery. Forest ownership has so improved the bargaining position of the Companhia that fuelwood can be purchased from outside sources at not more than half the usual market price.

The Companhia has its own Forest Service, which is centered at Río Claro but has personnel on all of the properties. The work of this Service has included land acquisition, regeneration, management, harvesting, utilization, and research.

One of the most significant aspects of the forestry project of the Companhia has been the importance attached to research. Navarro was by nature an investigator and at all times had an array of experiments in progress. He so completely sold the directors on the value of this research that he was provided a laboratory and adequate funds to carry out an extensive investigative program in the field. Since his death in 1941 research has continued to hold its place of importance under the direction of Armando Navarro Sampaio, an agronomist and the nephew of Edmundo. There can be no doubt that it was largerly this sympathetic attitude toward reseach which has made the project a success.

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* The description of the Companhia project is based upon observations made by the senior author during a visit to Rio Claro in July 1952. He is indebted to Armando Navarro Sampaio an his assistants, Rubens Foot Guimanaes and Jayme Vieira Pinheiro for the data presented.

The research division now includes two agronomists and a number of assistants. It has good laboratory facilities and a fund of data from the plantations throughout the State as basis for investigations. The early work was characterized by remarkably complete record-taking, the benefits of which are now readily apparent.

Those observations made in Brazil which appear to be of some value to Puerto Rico are here presented. Subsequently Puerto Rican experience is described, and finally conclusions are drawn as to what should be done in the future in Puerto Rico, in the light of results to date in both places.

Selection of Species

The suitability of a tree species for forestry is dependent upon its adaptability, productivity, and utility. The selection of superior species on the basis of these characteristics has formed an important part of the work in Brazil and should be of value elsewhere.

Adaptability

The spectacular growth rate of eucalyptus trees led to investigation of the home environment of this genus in Australia and the introduction of additional species in an effort to determine which would be most productive. A total of 143 species of eucalyptus were tested. A list of these appears as Appendix I.

The Río Claro environment is subtropical and moist. The temperature range is from 35º to 102ºF. and the mean is 70ºF. Precipitation average about 53 inches annually. The winter months are dry, the mean precipitation por each month from April to September being not more than 3 inches, and less than 1.5 inches during July and August. A period of four rainless weeks or more is experienced nearly every year. Windstorms are rare. The soils are mostly lateritic red clays, usually heavy but sandy in limited areas. Their pH range is from 4.5 to 6.5. They are generally more than 3 feet in depth and are well drained. They are degraded, having been farmed and abandoned prior to purchase by the Companhia.

The first tests of adaptability were small plantations of 20 x 20 trees within an isolation strip. A few trees of nearly all of the species tested are still to be seen, a fact which makes possible a complete appraisal of relative adaptabilities. Of those not adapted, a few did not survive, whereas others grew slowly and/or produced trees of poor from. A significant finding was that trees which fell behind in the first 6 months after planting never grew satisfactory later. The list of adapted species which is appended excludes all those of poor form or which produced trees too small for good utilization.

Species which proved adapted in the initial plantings were subsequently planted widely on other properties of the Companhia where environmental conditions differed slightly. These plantings led to certain conclusions regarding adaptability, some of which were of a general nature, and others concerned individual species. Eucalyptus generally has proven sensitive to the quality of the soil, particularly its depth. Poor sites have been reflected in slow growth. Hardpans are an adverse factor until the roots penetrate them. Soil acidity appears to be of little importance within the range tested. All species of Eucalyptus preferred the most humid climate tested, although the range was slight. The small temperature range is of no apparent significance. *Alba* seems to be one of the best species for adverse sites, and on swampy soils *robusta*, *camaldulensis*, and *umbellata* are most satisfactory. Additional data of this nature are available in "O Eucalipto"1/.

Productivity

Productivity is an important factor in the selection of tree species. Experience of the

1/ Navarro de Andrade, E. 1939. O. Eucalipto. Chacaras e Quintais, Sao Paulo. Pp. 121.

Companhia is not adequate to fully answer many questions, since long-range investigations of different management techniques are required. Nevertheless some important indications are evident.

Ease of propagation has not yet proven to be a factor in the selection of species in Sao Paulo. Differences are of minor importance and do not affect costs or results materially. Germination is generally high, 90 percent or better. It is highest in *camaldulensis* and *saligna* and lowest in *paniculata* (seldom much over 80 percent). Species with small seeds generally germinate well but must be transplanted in the nursery. Of these, *camaldulensis* and *saligna* survive transplanting well and *robusta* and *punctata* poorly. Species with large seeds and not requiring transplanting in the nursery include *citriodora, maculata, microcorys,* and *pilularis.*

Ease of establishment in the field does not vary greatly among the different species. Under local conditions all species must have a ball of earth about the roots for field planting. Survival is generally high, regardless of species. There has also been no observed difference among the species as to need for early plantation care. The plantations are generally quite uniform in early height growth.

Subsequent growth rates vary considerably. Table 1 shows average diameter growth in 3-½-year-old eucalyptus plantations with two spacings on a sandy soil. Greater differences would be expected on clay soil.

A comparison of older plantations (23 years) on clay soil showed little difference in diameter among the adapted species. About 150 trees of each species formed the basis of measurement. The most rapid was *kirtoniana* with an average diameter of 12.4 inches. Next was *saligna,* with 10.8 inches. Other species ranged from 8.4 to 10.0 inches.

Little difference in the tolerance of the various species has been noted. Species which persist most when suppressed are *alba, kirtoniana, punctata, saligna, propinqua,* and *umbellata.*

Table 1.—Diameter growth of young Eucalyptus

Species	Average diameter at breast height after 3-½ years	
	8.5-foot spacing	6.5-foot spacing
	Inches	Inches
kirtoniana	4.2	
saligna	4.0	
botryoides	3.3	
alba	3.7	4.4
punctata	3.3	3.7
robusta	3.0	
umbellata	2.8	3.8
camaldulensis	2.8	3.5
propinqua	2.0	
resinifera		3.6
maculata		3.2
citriodora		3.0
microcorys		3.0
paniculata		2.3

Susceptibility to disease and insect attacks does not yet differentiate the species tested. The most important insect pests, leaf cutting ants and termites, are not selective.

None of the species reproduces itself naturally in sufficient abundance to make unnecessary periodic replanting. Sparse natural reproduction of *citriodora* and *maculata* was seen. Absence of natural regeneration is believed partly due to the dry weather during the winter months when fruiting takes place and partly to the difficulty of seed contact with the soil.

The sprouting capacity of the different species, a reflection of their vigor, is directly related to growth rates. The average diameter of sprouts 15 years after the first cutting of 8-year old trees on a good clay soil is shown for several species in Table 2.

Additional information is available on page 40 of "O Eucalipto."

Table 2.—**Fifteen-year sprout growth**

Species	Average diameter at breast height after 15 years	
	With one sprout	With three sprouts
	Inches	Inches
paniculata	7.2	5.2
propinqua	7.2	
saligna	6.8	6.0
resinifera	6.4	5.6
robusta		5.6
alba	6.4	5.2
camadulensis		5.2

Data on taper of various species are not very complete, but in one study of large trees *robusta* with an average taper of 0.12 inch per lineal foot was one of the best formed species.

No important difference in the wind resistance of the various species has been noticed. There is a slight indication that *umbellata* withstands wind better than the average. None withstand major storms well.

The average diameter and density of older plantations of the different species is indicated in Table 3. Here are listed data from plantations 400 meters square established at an initial spacing of 6.5 feet and unthinned for 24 years. Table 3 shows a great uniformity among these species both as to average diameter and number of trees per unit of area. The basal area is very low, considering that no thinning has been done. This and the small percentage of suppressed trees shown in the final column are evidence of the intolerance of these species.

Table 3.—**Tree diameter and stand density in old plantations**

Species	Average d.b.h.	No. of trees per acre	Basal area per acre	Percent of suppressed trees
	Inches	No.	Sq. ft.	%
alba	10.0	74	40	15
botryoides	9.6	67	34	27
citriodora	9.2	71	33	21
maculata	10.1	53	29	
punctata	9.7	68	35	20
resinifera	9.4	70	34	16
robusta	9.5	71	35	7
saligna	10.5	76	46	20

A consideration of all production factors leaves the impression that present knowledge does not indicate that any adapted species should be eliminated from the list on this account.

Utility

Among those species which are adapted and comparatively easy to produce the best are those with products of greatest utility. For furniture the best species among those adapted are *botryoides, camaldulensis, citriodora, cladocalyx, maculata, pilularis, saligna* and *umbellata*. All of these species have attractive wood which takes a high polish. They are not all easily worked but can be used. *Robusta* heartwood was rejected because of splitting. Species used for construction include *botryoides, camaldulensis, maculata, paniculata, pilularis, punctata, saligna, triantha* and *umbellata*.

For railroad ties there is little preference. A few woods, such as that of *robusta*, split excessively. Nearly all species are on a par for posts and piling. The untreated heartwood of most species (even *robusta*,) lasts up to 10 years at Río Claro. Preservation of the heartwood has proven difficult at Río Claro because it will not absorb preservative by usual pressure treatment methods.

The relative suitability of different species for pulp has not been tested at Sao Paulo. A number of species, including *alba*, *grandis* and *saligna* are said to have been found satisfactory elsewhere and undoubtedly many others deserve study. Essential oils extracted from *globulus* and *citriodora*, were found satisfactory for medical use and for perfume. The bark of *punctata* is about 26 percent tannin.

Propagation

The Companhia has found natural hybridization common in eucalyptus. As a result, large isolated plots of each species have been established as sources of typical seed. These plots are usually 400 trees square and are surrounded by a 500-meter isolation strip of the same species. Trees within these plots are selected individually for form and for the conformance of the leaves, flowers, and fruits with type descriptions from Australia.

The fruits are dried in long concrete beds and covered at night for protection from daw. They are exposed to direct sunlight and in good weather they release all seeds in 2 days. The seeds are sown in concrete beds of 1 by 3 meters.About 30,000 seeds are sown at a time. The bed is covered with grass thatch during the period of germination. Subsequently seedlings are covered only for protection from extremes of insolation or rainfall.

Pots are made of compressed compost by a special machine. Seedlings are transplanted into them when about 1 inch tall, except for delicate species such as *citriodora*, which are sown directly in these pots. Planting in the field is done when the stock is 8 to 12 inches tall.

Selection of seedling and stock is directed toward greater uniformity of growth in the field. Because of better growth and form a selected stand outyielded others by 570 cubic feet per acre at 8 years of age. Selection is made on the basis of size and form. Of 30,000 seeds sown, about 25,000 germinate, of which the 10,000 best seedlings are chosen for transplanting. About 8,000 of these are selected for field planting. Investigation showed a field spacing of 6 feet to be superior in yield to 8 feet.

Management

Eucalyptus is usually planted on recently abandoned cleared lands. Sometimes a farmer clears and crops the land for 18 months, giving one third of his crop to the Companhia. Then he cleans up the crops, plants the trees at half the usual price and cares for them for 18 months without crops. A mixture of agricultural and tree planting (taungya) has not been tried.

Natural regeneration is most prominent in *citriodora*, *propinqua*, and *maculata*, but in no instance does sufficient regeneration take place to be of silvicultural significance.

The cutting regime for fuelwood is:

1. Cut clear at 7 year.
2. Thin to 3 or 4 sprouts per stump 8th year.
3. Thin to 1 sprout per stump in 13th year.
4. Cut clear at 20 years.
5. Repeat cycle, with step 2 above in 21st year.

The gradual removal of the sprouts is believed desirable to avoid a major shock at short intervals (of 7 years) and a resulting unbalance between root and tops. The sprouts come up successfully through light brush. This cycle may be repeated at least five times and is discontinued when 35 percent of the stumps are dead. The selection of sprouts in thinning is based upon diameter, form, and their isolation from each other at the base. Height growth of sprouts is less than for seedlings, as is the volume of a coppice stand at 7 years.

For power line poles the stand is thinned at 5, 10, and 15 years and the final cut is at about 20 years. Such poles are 8 inches in diameter at the small end and 32 feet long.

For saw timber the thinning regime is the same except that the best stems are left to 30 to 35 years. Some saw timber is also produced by coppice with standards. A few trees may be cut each year late in the saw timber rotation.

All plantations are cleaned every year throughout the rotation. The brush (not the grass) is cut to help tree growth and to facilitate exploitation. Cleaning costs about two man-days per acre.

Excessive thinning produces profuse epicormic branching, except possibly with *umbellata* and *punctata*.

No data are available on soil maintenance beneath the plantations. Herbaceous vegetation is persistent and slopes are gradual, so erosion is no serious problem. It was estimated that a growing plantation drops 6 tons of leaves per acre per year. No chemical analysis of the leaves has been made.

The trees are utilized to a 1-inch top for fuelwood, which is extracted in carts. Poles and logs are skidded with oxen.

Yields

Typical growth on good soil (*umbellata*) is as shown in Table 4

Table 4.—**Growth of** *Eucalyptus umbellata*

Age	D. B. H.	Height
Years	Inches	Feet
6	5.2	41
12	8.2	64
18	13.0	82
24	18.1	

The growth of *robusta* at Río Claro on a good clay soil is as shown in Table 5.

Table 5.— **Growth of** *Eucalyptus robusta*

Age	D. B. H.
Years	Inches
2	2.2
4	4.1
6	4.9
8	6.0
10	6.6
20	8.7

The production of a typical species (*umbellata*), based upon measurement of 3,340 hectares, was as shown in Table 6.

Table 6.--**Volume yield of** *Eucalyptus umbellata*

Age	Volume
Years	Cu. ft./acre
6	2,300
7	2,830
8	3,480
9	3,600
10	3,720
12	3,950
15	4,250

Utilization

Prior to sawing for lumber, logs are dried 6 months in the shade with ends painted. The lumber of eucalyptus produced at Río Claro is largely of low grade. It is cut with a gang saw. Warping is serious. Further investigation is required to improve the utilization of large trees suited for lumber.

Crossties are cut from logs which will yield two ties in cross section. This reduces checking since the center of log is not in the center of the tie. Then three cuts ½ inch wide and ½ inch deep are made longitudinal down the surface nearest the bark to reduce the tangential tension. This method successufully controls checking. The ties are cut from heartwood which in no species absorbs preservative. Nevertheless they are painted with carbolineum and are durable for 10 years or more.

Posts are dried 3 months so that checking is complete before treatment. Small posts are made from material quartered green to avoid checking. Preservative treatment is done with wolman salts, using vacum and pressure. The sapwood absorbs the preservative completely, and when treated, lasts from 10 to 25 years. With wolman salts the posts may be treated green if preferred. Cold soaking with wolman salts takes about 7 days. In hot and cold bath with creosote, power line pole butts are treated 8 hours at 120º C and then 2 to 3 hours cold.

Pulp and paper are soon to be made from eucalyptus in a new plant at Jundiai being constructed by private capital. Oils and tannins have proven too costly to extract commercially.

EXPERIENCE WITH EUCALYPTUS IN PUERTO RICO

Puerto Rico, in common with most countries of Latin America, has been attracted to eucalyptus and has tested various species on a number of different sites. As in Brazil, the local interest in the genus came largely as a result of the spectacularly rapid growth of a few trees which were introduced into the island probably for medicinal purposes. The prospect of high yields per acre of a variety of different types of woods from species adapted to adverse sites as indicated in literature descriptive of eucalyptus, is particularly attractive on a densely populated island.

Eucalyptus is apparently a relatively recent introduction into Puerto Rico. No record of its presence in the island could be found prior to 1900. Between 1920 and 1940 the Puerto Rico Forest Service introduced some 23 species. Since 1940 an additional 27 species have been introduced by the Tropical Forest Experiment Station. A complete list of the species introduced follows:

E. affinis H. D. et J. H. M.
E. alba Reinw.
E. albens F. v. M.
E. bicolor A. Cunn.
E. botryoides Smith.
E. calophyla R. Br.
E. camaldulensis Dehnh.
E. cinerea F. v. M.
E citriodora Hook.
E. cladocalyx F. v. M.
E. cornuta Labill.
E. diversicolor F. v. M.
E. fastigata.
E. globulus Labill.
E. goniocalyx F. v. M.
E. grandis Maiden.
E. gummifera (Gaertn.) Hook.
E. gunnii Hook.
E. hemiphloia F.v. M.
E. kirtoniana F. v. M.
E. longifolia Link & Otto.
E. maculata Hook.
E. maidenii.
E. marginata Smith.
E. melliodora A. Cunn.
E. obliqua L' Herit.
E. occidentalis Endl.
E. paniculata Smith.
E. pauciflora Sieb.
E. paulistana.
E. pilularis Smith.
E. polyanthema Schauer.
E. propinqua, H. D. & J. H. M.
E. punctata DC.
E. racemosa F. v. M.
E. resinifera Smith.
E. robusta Smith.
E. rostrata Schlecht.
E. rubida H. D. & J. H. M.
E. rudis Endl.
E. salicifolia Ca.
E. saligna Smith.
E. sideroxylon A. Cunn.
E. stricta Sieb.
E. stuartiana F. v. M.
E. torrelliana F. v. M.
E. tricntha Link.
E. umbellata (Gaertn) Domin.
E. umbra R. T. Baker.
E. viminalis Labill.

Adaptability

The adaptability of the species of eucalyptus introduced is not as completely known in Puerto Rico as in Brazil. Many of the introductions produced too few seedlings for extensive trials. In the beginning, the absence of funds for planting on public lands made it necessary to distribute the trees to any farmer interested. This resulted in concentration in a few areas

of the island where many eucalyptus species have since proven unadapted. In addition, written records of the results of planting prior to 1932 were lost in the hurricane of that year. Only recently has information begun to accumulate from systematic testing on a variety of promising sites.

Nearly all of the plantings of eucalyptus in Puerto Rico have been made either below 500 feet elevation along the coast or between 2,000 and 3,500 feet elevation in the mountains. Most of the low elevation sites are in a tropical moist climate, with temperature between 60º and 90º F and precipitation between 50 and 120 inches annually. Usually at least 3 inches of precipitation is received during the driest months, from February to April. Soils are mostly clay, derived from volcanic and sedimentary rocks.

In the mountains the climate is subtropical and wet, with temperatures generally between 50º and 85º F and precipitation ranging from 85 to 120 inches annually. Soils are friable to heavy acid clays, usually deep, and derived from volcanic rocks.

Studies of relic plantations from early introductions and of the results from recent experiments lead to a number of general conclusions regarding the adaptability of these eucalyptus species tested in Puerto Rico. The most important of these follow.

1. Climatically they seem better suited to the mountains than the coast. Judging from the literature on the natural range of these species, this is probably as much as reaction to temperature as to precipitation.
2. Where climatic conditions are satisfactory they are remarkably adaptable to soils which have been abused by excessive cultivation.
3. Where adapted they have, by a wide margin outgrown in diameter and height nearly all other trees native or exotic.
4. Where adapted they produce trees of better form than most other species.
5. No species yet tried, even under apparently favorable conditions, develops a sufficiently dense canopy in 10 years to dominate native vegetation, including grass, vines and trees.

A summary of the adaptability of the different species of eucalyptus which have been most extensively tested appears in the Thirteenth Annual Report of the Tropical Forest Experiment Station in this same issue of this journal and thus need not be repeated in detail here. Only a few of the most favorable species-site relationships will be described.

At low elevation only three species, *alba, kirtoniana,* and *umbellata,* have proven adapted. In the mountains the well adapted species are *kirtoniana, resinifera,* and *robusta,* and *maculata* is promising. Other species tested extensively but nowhere yet found well adapted include *trianthe, botryoides, citriodora, gummifera, globulus, pilularis, propinqua,* and *sideroxylon.* Some of these produce a few good trees per acre, but do not make uniform stands. Others grow slowly. Several might prove successful if planting were not limited to soils which have been degraded by cultivation.

Propagation

The two species of eucalyptus most generally planted, *robusta* and *kirtoniana,* are considered easy to propagate and establish on appropriate sites. Propagation both on the coast where the mean temperature is 78º F and precipitation is about 70 inches annually and in the foothills at 500 feet elevation with a mean temperature of about 74º F and precipitation of 120 inches annually has shown the latter location most favorable. Growth is more rapid and mortality is lower. The following description aplies to the foothills nursery.

The seed is sown in raised seed beds constructed of concrete (see Fig. 1). The soil in these beds is a mixture of equal parts of clay loam, filter press cake, and coarse sand. The freshly sown beds are protected from excessive sun and hard rains by removable corrugated metal shades. Sowing is done at the rate of one pound to 50 square feet of bed. As a precaution against damping off the soil is treated prior to sowing with formalin or copper sulphate and later the soil is sometimes treated with Bordeaux mixture. In spite of this, damping off is frequently a problem, and other methods of control are being tested.

This heavy sowing produces a very dense stand of seedlings. The yield per pound of seed varies between 6,000 and 15,000 seedlings. After 8 to 12 weeks in the seed beds the trees are from 2 to 4 inches tall. (See Fig. 2). Then the seedlings are gradually transplanted over a period of 2 or 3 weeks, selecting the largest first. The soft soil is moistened throughly so that individual seedlings can be pulled up without damaging the roots.

The seedlings are transplanted to conventional, slightly raised transplant beds (see Fig. 3) at a spacing of 3 x 6 inches. Transplanting is done with a dibble. Tests of a transplant board with these tiny seedlings have not yet been successsful. Transplanting losses are insignificant, and watering needed. After 8 to 10 weeks in the transplant beds the stock is 18 to 30 inches tall and is ready for lifting.

The trees are transplanted bare-rooted to the field and planted at a spacing of from 6 to 8 feet. Planting survival ranges from 75 to 90 percent. Despite the rapid growth of eucalyptus the young trees must be weeded twice annually for about 2 years to free them from competing native vegetation. All weeds within 18 inches of each tree are cut back to the ground level. After 2 years the trees are usually at least 2 feet above the other vegetation and need no further assistance, except possibly occasional liberation from vines.

Eucalyptus robusta and *kirtoniana* on favorable sites are subject to few insect attacks and disease. The chief problem of this nature affecting management is the dying of single trees throughout the life of the stand. Usually mortality of this type is preceded by die-back in teh crowns, and sometimes by gum exudation and worthless sprout growth at or near the base of the trunk. On many sites this type of mortality keeps the canopy sufficiently open to prolong the vine problem and encourages a dense growth of native vegetation to invade beneath the plantation.

Management

Puerto Rico's plantations of eucalyptus cover probably less than 2,000 acres. They are mostly young and many of them are merely scattered tests of site adaptability. Thus no fixed management techniques such as those of Brazil have been established. Nevertheless, observations have been made which indicate a few desirable practices.

On the best sites thinning is apparently needed before the tenth year. The chief sympton of this condition is the early reduction in the height and size of the crowns. A canopy sufficiently dense to indicate a need for thinning never develops, nor does the thick herbaceous cover beneath the trees disappear. The growth rate of the upper canopy trees declines slowly with crown size and the harvest of subordinate stems becomes desirable for economic reasons.

The production of the largest timber for which eucalyptus seems suited in Puerto Rico, power-line poles, calls for a rotation of from 15 to 20 years. During this rotation one or two thinnings will generally proves desirable.

Artificial reforestation with eucalyptus, including weeding and vine removal, cost 20 mandays per acre, so the development of natural methods of regeneration is very desirable. Prospects for such a method do not appear bright, however, since natural seedlings of eucalyptus are almost never found, and sprouting of trees of 10 inches or more in diameter is weak.

Fig. 1.—Concrete seed beds with removable shades usted for the propagation of Eucalyptus. (Lechos de hormigón con cobijas removibles usados parc la propagación de Eucalipto).

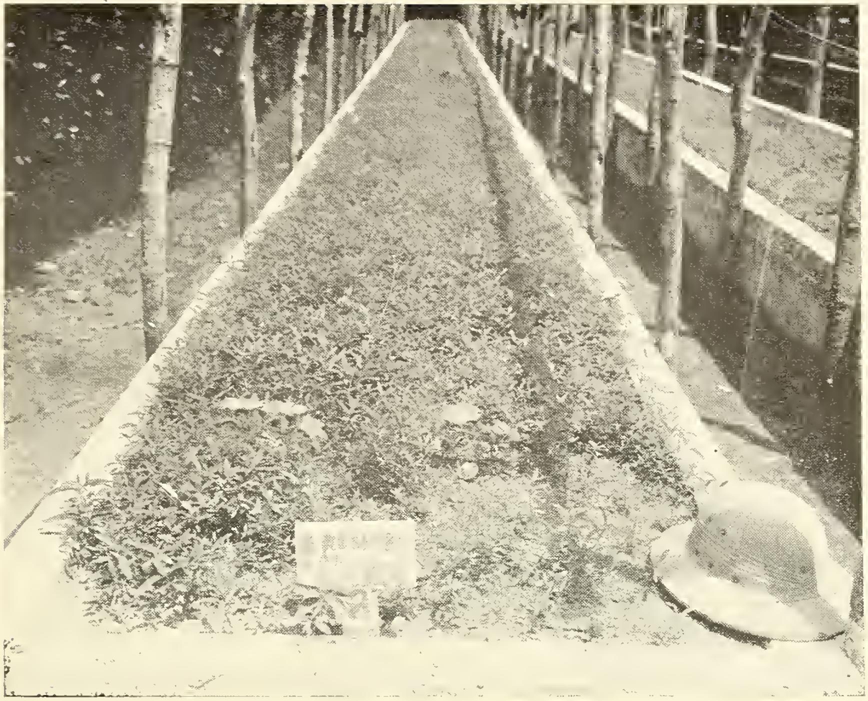

Fig. 2.—Dense stand of Eucalyptus seedlings 8 weeks old and ready for transplanting. (Rodal denso de semillones de Eucalipto de 8 semanas y listos para ser trasplantados).

Fig. 3.—Nursery beds recently planted with Eucalyptus. (Lechos en el vivero sembrados recientemente con Eucalipto).

Growth

No data as to the productivity of eucalyptus in Puerto Rico are available except in terms of average tree diameters in plantations of known ages. A volume table is in preparation which will show volumes in cubic feet to different top diameters.

Important differences in growth rates are not yet generally evident among the adapted species. At low elevation 8-year old plantations of *alba, kirtoniana,* and *umbellata* range from 3 to 9 inches d. b. h. and from 40 to 75 feet tall. In the mountains 13-year old plantations of *kirtoniana,* and *,robusta* range from 6 to 16 inches d. b. h., and from 60 to 90 feet tall, the former the taller; and the latter the larger in diameter. Additional growth data appear in the Annual Report elsewhere in this journal.

An encouraging result of growth studies is that under one condition, a least, rapid growth continues to a large size. In a 24-year old widely spaced plantation of *robusta* on lateritic clay at 2,000 feet elevation the average annual diameter growth for 48 trees during the past 5 years was 0.31 inch. For 15 trees of more than 12 inches dbh, it was 0.41 inch. One 16-inch tree grew at the rate of 0.82 inch per year.

Utilization

To the present the utilization of eucalyptus has not been a problem in Puerto Rico. The few trees which have reached large size are used for poles or fuelwood. Nevertheless a problem of utilization may arise in the future because an increasing area is being dedicated to eucalyptus, yet no traditional use of these species or means for preserving the wood are available locally. Eucalyptus has been planted here primarily because it grows so much faster and straighter on poor sites than other trees. It has been assumed that in an area so densely populated as Puerto Rico, with so few forest resources that almost any wood, if uniform, cheap, and available in quantity would find a market. The development of such a market is needed soon to provide an outlet for the increasing production of established plantations and to serve as an incentive for more planting, particularly on privately owned lands.

The lumber of *robusta* and *kirtoniana,* warps seriously, a fact which apparently restricts utilization to poles, posts, and possibly pulpwood. The wood has been found perishable in the ground. Fence posts generally remain serviceable only 24 to 36 months, about the same period as most native posts.

Tests of preservative treatment show that by the hot and cold bath method an absorption of 6 to 8 pounds of carbolineum per cubic foot is possible. The durability of treated posts is not yet known.

Robusta has recently been used for subsurface piling. Piling of up to 50 feet in length have been found as satisfactory in every respect as imported pine, and they seem to withstand driving better. This may prove to be one of the highest uses of eucalyptus in Puerto Rico.

CONCLUSIONS

A number of conclusions arise from a comparison of experience with eucalyptus at Sao Paulo and in Puerto Rico. The greater fund of knowledge available at Sao Paulo makes this comparison particularly helpful to Puerto Rico. The major conclusions reached are here listed.

1. Fewer species have so far proven adapted to Puerto Rico than to Sao Paulo. Nevertheless those adapted to Puerto Rico are also among the better species at Sao Paulo.

2. The investigation of eucalyptus in Puerto Rico has barely scratched the surface. Many species have been set aside on the basis of very limited tests. More extensive plantings should be made with the better species,

regardless of past experience. Better soils, should be tested, because good species of eucalyptus might well compete in yield with other farm crops under favorable environmental conditions. Species particularly worthy of more planting are *alba, botryoides, camaldulensis, triantha* and *umbellata*.

3. More attention should be paid to species, seed sources, and selection in the nurseries. Both at Sao Paulo and in Puerto Rico a number of unknown species or hybrids exist. These should be identified and seed sources protected accordingly. For the present seed for testing should be obtained from reliable outside sources. The results of selection of uniform seedling in the nursery should be tested locally.

4. The establishment of eucalyptus plantings immediately subsequent to cultivation, as is done at Sao Paulo, and during the cultivation period also should be tested to make reforestation with these species simpler and more attractive for the farmer.

5. Management experiments to determine the results of different thinning regimes an to explore the posibilities of reproduction by coppice are also needed to assure maximum yields.

6. Productive understory crops should be developed. The continuous need for weeding at Sao Paulo and the invasion of native trees beneath plantation in Puerto Rico indicate that there may be a place for a secondary crop beneath the trees. Bananas and coffee are possibilities worthy of trial.

7. A local preservation plant such as is available at Sao Paulo must be set up soon to make possible the marketing of the large volume of poles which will soon be available in the plantations. Studies of the pulping properties of local species are also needed if complete utilization is to be achieved.

APPENDIX I

Species of Eucalyptus Tested by the Companhia Paulista

acaciaeformis
acervula Hook (syn. *ovata*)
affinis H. D. et J. H. M.
alba Reinw.
albens Miq.
x *algeriensis**
amplifolia Naudin.
andrewsi J. H. M.
angulosa
x *antipolitensis*
*baileyana** F. v. M.
bakeri
bicolor A. Cunn.
bosistoana F. v. M.
*botryoides** Smith
caleyi J. H. M.
*calophylla** R. Br.
*camaldulensis** Dehnh. (syn. *rostrata*)
x *camaldulensis** x *resinifera**
cambageana J. H. M.
camphora
*capitellata** Smith
cinerea F. v. M.
*citriodora** Hook
*cladocalyx** F. v. M. (syn. *corynocalyx*)
coccifera Hook
conica H. O. & J. H. M.
consideniana J. H. M.
cornuta Labill.
dowsoni R. T. B.
dealbata
deanei J. H. M.
decipiens Endl.
decurva
diversicolor F. v. M.
dives Schauer
drummondi
dumosa (syns. *ovata* & *johnstoni*)
elaeophora F. v. M.
erythronema Turez.
*eximia** Schauer
exserta

* Species which have proven well adapted at Río Claro.
x - hibrid.

fasciculosa F. v. M.
falcata
ficifolia F. v. M.
foecunda Schauer
globulus Labill.
gomphocephala F. v. M.
*goniocalyx** F. v. M.
grandifolia
griffithsii J. H. M.
guilfoylei J. H. M.
*gummifera** (Gaertn.) Hookr.
*gunnii** Hook
haematoma DC.
hemiphloia F. v. M.
hubrida J. H. M.
incrassata Lab.
kirtoniana F. v. M. (*grandis**)
*kirtoniana** F. v. M. (syn. *patentinervis*)
laevopinea R. T. B.
lehmannii Preiss.
leucoxylon F. v. M. (syn *creacilipes*)
*linearis** A. Cunn.
*lindleyana** (syns. *andreana, numerosa*)
longifolia Link & Otto.
loxophleba Benth
macarthure H. D. et J. H. M.
macrocarpa Hook
macrorrhyncha F. v. M.
*maculata** Hook
maculosa R. T. B.
*maideni**
marginata Smith
megacarpa F. v. M.
melanophloia F. v. M.
melliodora A. Cunn.
microcorys F. v. M.
microtheca F. v. M.
moorei J. H. M. (syn. *microphylla*)
morissi (*morrisii*)
muelleriana A. W. Howitt.
obliqua L' Herit
obtusiflora
*occidentalis** Endl.
ochrophloia F. v. M.
odorata Behr.
oleosa F. v. M.
*oranensis**
*paniculata** Smith
patens Benth.
pauciflora Sieb. (*syn. coriacea*)
x *paulistana**
*pilularis** Smith
*piperita** Smith
planchoniana F. v. M.
platypus Hook (*syn. obcordata*)
polyanthemos Schauer
populifolia Hook
pressiana Schauer
*propinqua** Deane & Maiden
puverulenta Sims (syn. *pulvigera*)
*punctata** DC.
*racemosa** F. v. M. (syn. *creba*)
redunca Schauer
regnans F. v. M.
*resinifera** Smith
*robusta** Smith
*rubida** Deane & Maiden
*rudis** Endl.
salicifolia (Sol.) Cav. (syn. *amygdalina*)
*saligna** Smith
salmonophloia F. v. M.
salubris F. v. M.
*scabra** (syn. *eugenioides*)
sieberiana F. v. M.
*siderophloia** Benth.
sideroxylon A. Cunn.
*smithii** R. T. B.
stellulata Sieb.
stricta Sieb.
stuartiana F. v. M.
squamosa H. D. et J. H. M.
tetragona (syn. *pleurocarpa*)
*umbelleta** (syn. *tereticornis*)
x *trabuti**
triantha Link (syn. *acmenioides**)
*umbra** R. T. Baker
uncinata Turez.
urnigera Hook
*viminalis** Labill.
viridis (syn. *acacioides**)
woolsiana R. T. B.

(Traducción del artículo anterior)

Experiencias de la Companhia Paulista con Eucalipto

Su Importancia para Puerto Rico *

La Companhia Paulista de Estradas de Ferro centralizada en Sao Paulo ha llevado a cabo lo que es probablemente el mayor proyecto individual de dasonomía hasta la fecha emprendido en la América Latina. Los resultados son de gran importancia no sólo para el Estado de Sao Paulo y para el Brasil, sino para todos los países en las regiones tropicales y subtropicales de este hemisferio. Es especialmente significativo que este proyecto haya sido realizado por una empresa privada que como tal ha tenido que triunfar tanto en lo económico como en lo técnico.

A principios de este siglo directores previsores de la Companhía empezaron a preocuparse por la creciente escasez de leña a lo largo de sus líneas ferroviarias en la parte este del estado de Sao Paulo. En 1903 nombraron a Edmundo Navarro de Andrade, un agrónomo, para establecer plantaciones de árboles como fuente de combustible para la Companhia.

Navarro inició sus experimentos en una propiedad de la Companhia en Jundiai, pocas millas al oeste de Sao Paulo. Sembró 95 especies distintas de árboles para determinar cuáles daban mayor rendimiento. El eucalipto de semillas de viejos árboles, residuos de las primitivas plantaciones de los Jesuitas, sobrepasó a todas las demás especies y por consiguiente se le sometió a más experimentaciones y plantaciones. El crecimiento de estas plantaciones impresionó de tal manera a los directores que se adquirieron más propiedades a lo largo del ferrocarril y en 1909 el centro de operaciones se trasladó a un área mayor en Río Claro.

El interés de la Companhia crecía según el trabajo de Navarro producía resultados espectaculares. Millones de cruzeiros se emplearon en el proyecto. Unas 17 plantaciones se han establecido a lo largo de las líneas de la Companhia. Se han sembrado más de 30.000.000 de árboles en alrededor de 12.000 hectáreas. La Junta de Directores comprendió tan cabalmente las valores indirectos y el largo plazo de los proyectos que autorizó inversiones en exceso de las ganancias individuales. Sin embargo el capital en terrenos y plantaciones y otros servicios es suficiente para asegurar la recuperación total. La posesión de bosques ha mejorado de tal manera el poder de contratación de la Companhia que la leña puede comprarse en fuentes exteriores a no más de la mitad del precio en el mercado.

La Companhia tiene su propio Servicio Forestal que está establecido en Río Claro pero tiene personal en todas las propiedades. El trabajo de este Servicio ha incluído la adquisición de tierras, regeneración, ordenación, cosechas, utilización e investigaciones.

Uno de los aspectos más significativos del proyecto de dasonomía de la Companhia, ha sido la importancia que se le ha dado a la investigación forestal. Navarro era investigador por naturaleza y a todo momento tenía un despliegue de experimentos en progreso. De tal manera convenció a los directores del valor de estas experimentaciones que éstos le proporcionaron un laboratorio y fondos adecuados para llevar a cabo un extenso programa de investigación. Después de su muerte en 1941 el trabajo de investigación ha mantenido su importancia bajo la dirección de Armando Navarro Sampaio, agrónomo y sobrino de Edmundo. No hay duda de que es esta actitud favorable

* Las notas sobre el proyecto de la Companhia están basadas en las observaciones del Dr. Wadsworth durante una visita que hizo a Río Claro en julio de 1952. Tiene que agradecer a la bondad de Armando Navarro Sampaio y a sus ayudantes Rubens F ot Guimanaes y Jayme Viera Pinheiro los datos aquí presentados.

hacia el trabajo de investigación lo que ha hecho del proyecto un éxito.

La división de investigaciones incluye ahora dos agrónomos y varios ayudantes. Tiene buenas facilidades de laboratorio y un caudal de datos sobre las plantaciones en todo el Estado como base para sus investigaciones. El trabajo en su principio se caracterizó por una notable copilación de datos cuyos beneficios son ahora palpables.

Se presentan aquí las observaciones hechas en el Brasil que parecen tener algún valor par Puerto Rico y en seguida se describen las experiencias puertorriqueñas; finalmente se ofrecen conclusiones sobre lo que debiera hacerse en Puerto Rico a la luz de los resultados obtenidos hasta la fecha en ambos sitios.

Selección de Especies

La conveniencia de una especie de árbol para la dasonomía depende de su adaptabilidad, productividad y utilidad. La selección de especies superiores desde el punto de vista de estas características, ha sido parte importante del trabajo en el Brasil y debiera tener importancia en cualquier otro sitio.

Lo espectacular en el ritmo de crecimiento del eucalipto condujo a investigaciones en el lugar de origen de esta especie australiana y a la introducción de especies adicionales en un esfuerzo por determinar cual sería más productiva. Se hicieron pruebas con 143 especies de eucalipto. Una lista de éstas aparece como Apéndice I.

La situación de Río Claro es subtropical y húmeda. La temperatura fluctúa entre 35º y 102ºF; la temperatura media es de 70ºF. Tiene un promedio de 53 pulgadas de precipitación anualmente. Los meses de invierno son secos con no más de 3 pulgadas de precipitación de abril a septiembre y 1,5 pulgadas durante julio y agosto. Casi todos los años hay una temporada de seca que dura 4 semanas o más. Vientos tormentosos son raros. Los suelos son de arcillas lateríticas rojas, generalmente pesadas pero arenosas en áreas limitadas. Su ritmo pH es de 4,5 a 6,5. Generalmente tienen más de 3 pies de profundidad y están bien drenados. Están degradados por haber sido cultivados y luego abandonados con prioridad a la compra por la Companhia.

Las primeras pruebas para adaptabilidad se hicieron en plantíos pequeños de 20 x 20 árboles en una faja aislada. Todavía se ven algunos árboles de cada una de las especies probadas lo que hace posible una evaluación completa de su relativa adaptabilidad. De las que no se adaptaron, pocas sobrevivieron, otras crecieron lentamente y/o produjeron árboles de forma pobre. Un hallazgo significativo es que los árboles que se retardaron durante los primeros 6 meses después de sembrados nunca crecieron satisfactoriamente. De la lista de las adaptadas que se anexa se excluyen todas las de forma pobre y las que dieron árboles demasiado pequeños para su buena utilización.

Las especies que se adaptaron en las primeras plantaciones fueron luego sembradas en otras propiedades de la Companhia donde la condición ambiental difería poco. Estas plantaciones llevaron a ciertas conclusiones relacionadas con la adaptabilidad, algunas de carácter general, otras relativas a especies individuales. El eucalipto siempre ha demostrado ser suceptible a la calidad del suelo, particularmente a la profundidad. El estar sembrado en suelos pobres se rerefleja en crecimiento lento. Bancos duros son factor adverso hasta que las raíces los penetran. La acidez del suelo parece de poca importancia dentro de las pruebas hechas. Casi todas las especies de eucalipto prefirieron los más humedos de los climas probados, aunque la diferencia era poca, la poca diferencia en temperaturas no parece tener importancia. La especie *alba* parece ser la mejor para sitios adversos y en suelos pantanosos *robusta, camaldulensis* y *umbellata* se dan satisfactoriamente. Datos adicionales sobre este aspecto se encuentran en "O Eucalipto"[1/].

1/ Navarro de Andrades. E. 1939. O Eucalipto. Chacaras e Quintais. Sao Paulo. Pp. 121.

Productividad

La productividad es factor importante en la selección de especies. Las experiencias de la Companhia no son adecuadas para contestar completamente a muchas preguntas, debido a que se requieren investigaciones de largo alcance sobre muchas técnicas de ordenación. Sin embargo algunas indicaciones importantes son evidentes.

La facilidad de propagación no ha sido hasta ahora factor en la selección de especies en Sao Paulo. Las diferencias son de poca importancia y no afectan materialmente ni el costo ni los resultados. La germinación es generalmente alta, 90 por ciento o más. Es más alta en *camaldulensis* y en *saligna* y más baja en la *paniculata* (rara vez más de 80%). Las especies de semilla pequeña generalmente germinan bien pero hay que trasplantarlas en el vivero. De éstas *camaldulensis* y *saligna* sobreviven a la transplantación pero *robusta* y *punctata* no. Las especies de semilla grande que no necesitan transplantación en el vivero incluyen *citriodora, maculata, microcorys* y *pilularis.*

La facilidad de acomodo en el campo no varía mucho entre las especies. Bajo condiciones locales todas las especies deben tener cepellón para sembrarse en campo. La supervivencia es generalmente alta en todas las especies. No se ha observado diferencia alguna entre las especies en cuanto al cuido temprano de la plantación. Las plantaciones son generalmente uniformes en cuanto al crecimiento temprano en altura. Luego el ritmo de crecimiento varía considerablemente.

La tabla 1 indica el crecimiento diametral promedio de plantaciones de eucalipto de 3-½ años en suelos arenosos espaciadas de dos distancias. Las diferencias serían mayores en suelos arcillosos.

Tabla 1.—Crecimiento diametral del eucalipto joven

Especie	Diámetro promedio a la altura del pecho a los 3-½ años	
	Espaciados de 2 metros	Espaciados de 25 metros
	Cms.	Cms.
kirtoniana	10,7	
saligna	10,2	
alba	9,4	11,1
botryoides	8,4	
punctata	8,4	9,4
robusta	7,6	
umbellata	7,1	9,7
camaldulensis	7,1	8,9
propinqua	5,1	
resinifera		9,1
maculata		8,1
citriodora		7,6
microcorys		7,6
paniculata		5,8

Una comparación con plantaciones viejas (23 años) en suelos arcillosos arrojó poca diferencia en diámetro entre las especies adaptadas. Unos 150 árboles de cada especie sirvieron de base para las mediciones. La más rápida fué la *kirtoniana* con un diámetro promedio de 31,5 centímetros. Le siguió *saligna* con 27,4 centímetros. Otras especies fluctuaron entre 21 y 25 centímetros.

Se ha notado poca diferencia en tolerancia entre las varias especies. Las especies que persisten más cuando dominadas son *alba, kirtoniana, punctata, saligna, propinqua* y *umbellata.*

Todavía no puede establecerse diferencia entre las especies estudiadas en cuanto a su susceptibilidad a enfermedades y a insectos. las plagas más importantes de insectos, las hormigas corta-hojas y los termes no escogen.

Ninguna de las especies se reproduce naturalmente lo suficiente para hacer innecesaria la replantación periódica. Se notó la reproducción natural escasa de la *citriodora* y la *maculata.* Se cree que la ausencia de regeneración natural se deba al tiempo seco durante los meses de invierno cuando tiene lugar

la fructificación y en parte a la dificultad de contacto de la semilla con el suelo.

La capacidad para retoñar de las diferentes especies, lo que refleja su fortaleza, se relaciona directamente al ritmo de crecimiento. El promedio diametral de los renuevos a los 15 años después de la primera corta, en árboles de 8 años en buen suelo arcilloso queda indicado para varias especies en la Tabla 2. Información adicional puede tenerse en la página 40 de "O Eucalipto."

Tabla 2.—**Crecimiento de renuevos a los 15 años**

Especies	Promedio diametral a la altura del pecho a los 15 años	
	Con un renuevo	Con tres renuevos
paniculata	18,3	13,2
propinqua	18,3	
saligna	17,3	15,2
resinifera	16,3	14,2
robusta		14,2
alba	16,3	13,2
camaldulensis		13.2

Datos sobre la disminución gradual de varias especies no son muy completos, pero en un estudio de árboles, *robusta*, con un promedio de disminución de 1 centímetro por metro lineal, se consideró una de las especies mejor formadas.

No se ha notado diferencia de importancia en la resistencia al viento entre las varias especies. Hay una ligera indicación de que la *umbellata* soporta el viento mejor que el promedio de especies. Ninguna soporta bien las grandes tormentas.

En la tabla 3 se indica el promedio diametral y la densidad de plantaciones viejas de diferentes especies. Aquí se apuntan los datos sobre plantíos de 400 metros cuadrados con espaciamiento inicial de 6,5 pies y sin clareos por 24 años. Como se verá en la Tabla 3 hay uniformidad entre las especies tanto en el promedio diametral como en el número de árboles por unidad de superficie. El área basal es muy baja visto que no ha habido clareo. Esto y el pequeño porcentaje de árboles dominados que se señalan en la última columna, demuestran la intolerancia de estas especies.

Tabla 3.—**Diámetro de árboles y densidad de rodal en plantaciones viejas**

Especie	Promedio a la altura del pecho	Número de árboles por hectárea	Area basal por hectárea	Por ciento de arboles dominados
	Cms.	No.	Metros cuadrados	%
alba	25,4	183	9,2	15
botryoides	24,4	165	7,8	27
citriodora	23,4	175	7,6	21
maculata	25,6	131	6,7	
punctata	24,6	168	8,0	20
resinifera	23,9	173	7,8	16
robusta	24,1	175	8,0	7
saligna	26,7	188	10,6	20

Una consideración de los factores relativos a la producción deja la impresión de que los conocimientos actuales no indican que deba eliminarse de la lista ninguna de las especies adaptadas.

Utilidad

Entre las especies que se han adaptado y que son relativamente fáciles de producir las mejores son las que dan productos de mayor utilidad. Para ebanistería las mejores especies entre las adaptadas son la *botryoides*, la *camaldulensis*, la *citriodora*, la *cladocalyx*, la *maculata*, la *pilularis*, la *saligna* y la *umbellata*. Todas éstas dan madera atractiva que pule bien. No todas son fáciles de trabajar pero pueden usarse. La *robusta* (duramen) fué rechazada porque se hiende. Las especies que se usan para construcción incluyen *botryoides*, *camaldulensis*, *maculata*, *paniculata*, *pilularis*, *punctata*, *saligna*, *triantha* y *umbellata*.

Para durmientes casi no hay preferencia. Algunas maderas como la de la *robusta* se rajan demasiado. Para postes y pilotes están al par. El duramen de madera sin tratar, de la mayor parte de las especies

(aún *robusta*) dura 10 años en Río Claro. La preservación de duramen se ha encontrado difícil en Río Claro porque éste no absorbe los preservativos por el método usual de tratamiento a presión.

La relativa utilidad de diferentes especies para pulpa no se ha comprobado en Sao Paulo. Se dice que un número de especies incluyendo *alba*, *grandis*, y *saligna* han resultado satisfactorias en otros sitios, e indudablemente hay otras que merecen estudio. Aceites esenciales extraídos de *globulus* y *citriodora* se han encontrado satisfactorios para usos medicinales y perfumería. La corteza de *punctata* contiene un 26 por ciento de tanino.

Propagación

La Companhia ha descubierto que la hibridización es común en el eucalipto. Como resultado, cuarteles aislados de cada especie se han establecido como fuentes de semillas típicas. Estos cuarteles tienen por lo general un cuadro de 400 árboles y están rodeados de una faja aisladora de 500 metros de la misma especie. Los árboles en estos cuarteles han sido escogidos individualmente por su forma y por la conformación de las hojas, flores y frutos a las descripciones de su tipo en Australia.

Los frutos se ponen a secar en lechos largos de concreto y se cubren de noche para protegerlos del rocío. Se exponen a luz directa del sol y en buen tiempo, sueltan las semillas en dos días. Las semillas se siembran en lechos de concreto de 1 por 3 metros. Se siembran unas 30.000 semillas a la vez. Se cubre el lecho con una cubierta de hierba durante la germinación. Más luego los semillones se protegen solamente contra extremos de insolación o lluvia.

Los tiestos se hacen de composte comprimido en una máquina especial. Los semillones se trasplantan a ellos cuando tienen como una pulgada de altura, con excepción de especies delicadas, como la *citriodora*, que se siembran directamente en los tiestos. Se siembran en el campo cuando el material tiene de 8 a 12 pulgadas de altura.

La selección de semillones y otro material de vivero tiende a lograr mayor uniformidad de crecimiento en el campo. Debido a mejor forma y mayor crecimiento, un rodal seleccionado sobrepasó en rendimiento a otros por 570 pies cúbicos por acre a los 8 años. La selección se hace a base de tamaño y forma. De 30.000 semillas sembradas unas 25.000 germinan, de las cuales los 10.000 semillones mejores se escogen para la trasplantación. Como 8.000 se seleccionan para siembra en campo. Las investigaciones han demostrado que un espaciamiento de 6 pies es superior en rendimiento a uno de 8 pies.

Ordenación

El eucalipto se siembra usualmente en terrenos desmontados y de reciente abandono. A veces un agricultor limpia y cultiva la tierra durante 18 meses dándole la tercera parte de su cosecha a la Companhia. Entonces recoge su cosecha, siembra los árboles por la mitad del precio usual y los cuida durante 18 meses sin cultivos. Una mezcla de agricultura y plantación de árboles (método taungya) no se ha ensayado.

La regeneración natural es más común en *citriodora*, *propinqua* y *maculata*, pero en ningún caso es suficiente para tener valor selvicultural.

El régimen de corta para leña es como sigue:

1. Corta total a los 7 años.
2. Aclareo dejando 3 o 4 renuevos por tocón a los 8 años.
3. Aclareo dejando 1 renuevo por tocón a los 13 años.
4. Corta total a los 20 años.
5. Repetición del ciclo, etapa 2 a los 21 años.

La remoción gradual de los renuevos se considera deseable para evitar cambios muy bruscos a intervalos cortos (de 7 años) y el consiguiente desequilibrio entre raiz y tope. Los renuevos crecen fácilmente por entre la

maleza. Este ciclo puede repetirse por lo menos cinco veces pero se descontinúa cuando el 35 por ciento de los tocones están muertos. La selección de renuevos en el aclareo se basa en el diámetro, la forma y el aislamiento de uno del otro en el tronco. El crecimiento en altura de los renuevos es menor que el de semillones como lo es también el volumen de un rodal de renuevos a los 7 años.

Para postes de energía eléctrica el rodal se aclarea a los 5, 10 y 15 años y la corta final es a los 20 años. Estos postes tienen diámetro de 8 pulgadas en la punta y miden 32 pies de largo. Para madera de aserraje el régimen de corta es el mismo excepto que los mejores tallos se dejan hasta los 30 o 35 años. Alguna madera de aserraje se produce también siguiendo el sistema de tallar con resalvos. Pueden cortarse algunos todos los años para fines de la rotación de madera de aserraje.

Todas las plantaciones se limpian todos los años durante la rotación. La maleza (no la hierba) se corta para ayudar en el crecimiento de los árboles y para facilitar la explotación. El coste de limpieza es de dos jornales por acre.

Clareo excesivo produce profusión de ramas de brotes en reposo con excepción, quizás, en la *umbellata* y la *punctata*.

No hay datos sobre la protección de suelos bajo las plantaciones. La vegetación herbácea es persistente y las laderas son llevaderas de manera que la erosión no es problema serio. Se ha calculado que una plantación en crecimiento suelta 15 toneladas de hojas por hectárea al año. No se ha hecho un análisis químico de las hojas. Los árboles se utilizan hasta la última pulgada de la punta para leña que se saca en carretas. Los pilotes y troncos son arrastrados por bueyes.

Rendimientos

Se indica en la Tabla 4 el crecimiento típico en buen suelo (*umbellata*).

Tabla 4—**Crecimiento de** *Eucalyptus umbellata*

Edad	Diámetro a la altura del pecho	Altura
Años	Cms.	Metros
6	13,2	12,5
12	20,8	19,5
18	33,0	25,0
24	45,9	

El crecimiento de *robusta* en Río Claro en buen suelo arcilloso se indica en la Tabla 5.

Tabla 5.—**Crecimiento de** *Eucalyptus robusta*

Edad	Diámetro a la altura del pecho
Años	Cms.
2	5,6
4	10,4
6	12,4
8	15,2
10	16,8
20	22,1

La producción de una especie típica (*umbellata*) basada en mediciones de 3.340 hectáreas queda indicada en la Tabla 6.

Tabla 6.—**Volumen de rendimiento de** *Eucalyptus umbellata*

Edad	Volumen
Años	Metros cúbicos por hectárea
6	160,8
7	197,8
8	243,3
9	251,6
10	260,0
12	276,1
15	297,1

Utilización

Antes de aserrarlos para madera los troncos se ponen a secar a la sombra por 6 meses, con las puntas pintadas. La madera de eucalipto que se produce en Río Claro es mayormente de calidad inferior. La cortan

con una sierra múltiple. El alabeo es serio. Se necesita mayor investigación para mejorar la utilización de árboles grandes propios para madera.

Las traviesas se cortan de troncos tan anchos que rinden dos. Esto reduce la tendencia a rajarse visto que el centro del tronco no está en el centro de la traviesa. Entonces se hacen tres incisiones de 1/2 pulgada de ancho y 1/2 pulgada de profundidad, longitudinalmente a lo largo de la superficie más cerca de la corteza, para reducir la tensión tangencial. Este método controla muy bien esta tendencia. Estas traviesas se cortan de duramen que en ninguna especie absorbe el preservativo. Sin embargo se pintan con un compuesto de creosota y duran 10 años o más.

Los postes se ponen a secar por 3 meses para dar tiempo a que todas las rajaduras naturales aparezcan antes del tratamiento. Los postes pequeños se hacen de material verde cortado en cuartos para evitar las rajaduras. El tratamiento preservativo se hace con sales Wolman usando vacío y presión. La albura absorbe el preservativo completamente y después de tratada dura de 10 a 25 años. Con sales Wolman los postes pueden tratarse verdes si se prefiere. La inmersión con sales Wolman requiere 7 días más o menos. Las bases de los postes de energía eléctrica se someten a un tratamiento de baños calientes y fríos con creosota 8 horas a una temperatura de 120ºC y luego 3 horas al frío.

Pronto se harán pulpa y papel del eucalipto en la nueva planta en Jundiai que se está construyendo con capital privado. Los aceites y el tanino han resultado demasiado costosos para extraerlos con fines comerciales.

EXPERIENCIAS CON EUCALIPTO EN PUERTO RICO

Puerto Rico, como la mayor parte de los países de la América Latina, se ha interesado en el eucalipto y ha ensayado con varias especies en distintos ambientes estacionales. Como en el Brasil, el interés local en la especie se debió en gran parte al crecimiento asombroso de algunos árboles que habían sido introducidos en la isla posiblemente con fines medicinales. La perspectiva de grandes rendimientos por acre de una variedad de maderas de especies adaptables a medios estacionales adversos como indican los informes sobre el euacalipto, tiene que ser de particular interés para una isla densamente poblada.

El eucalipto es de introducción reciente en Puerto Rico. No hay datos que indiquen su presencia en la isla antes de 1900. Entre 1920 y 1940 el Servicio Forestal de Puerto Rico introdujo 23 especies. Desde 1940 hasta la fecha la Estación de Experimentación Forestal Tropical ha introducido 27 especies más. Sigue la lista completa de estas especies.

E. affinis H. D. et J. H. M.
E. alba Reinw.
E. albens F. v. M.
E. bicolor A. Cunn.
E. botryoides Smith
E. calophylla R. Br.
E. camaldulensis Dehnh.
E. cinerea F. v. M.
E. citriodora Hook.
E. cladocalyx F. v. M.
E. cornuta Labill.
E. diversicolor F. v. M.
E. fastigata
E. globolus Labill.
E. goniocalyx F. v. M.
E. grandis Maiden.
E. gummifera (Gaertn.) Hookr.
E. *gunnii* Hook.
E. hemiphloia F. v. M.
E. kirtoniana F. v. M.
E. longifolia Link & Otto.
E. maculata Hook
E. maidenii
E. marginata Smith
E. melliodora A. Cunn.
E. obliqua L' Herit
E. occidentalis Endl.
E. paniculata Smith
E. pauciflora Sieba
E. paulistana
E. pilularis Smith
E. polyanthema Schauer

E. propinqua Deane & Maiden
E. punctata DC.
E. racemosa F. v. M.
E. resinifera Smith
E. robusta Smith
E. rostrata Schlecht
E. rubida Deanne & Maiden
E. rudis Endl.
E. salicifolia Ca.
E. saligna Smith
E. sideroxylon A. Cunn.
E. stricta Sieb.
E.stuartiana F. v. M.
E. torrelliana F. v. M.
E. triantha Link
E.umbellata (Gaertn) Domin.
E. umbra R. T. Baker
E. viminalis Labill.

Adaptabilidad

La adaptabilidad de las especies de eucalipto introducidas no se conoce tan bien en Puerto Rico como en el Brasil. Estas especies muchas de ellas produjeron demasiado pocos semillones para que se pudieran hacer extensas pruebas. Al principio la falta de fondos para hacer plantaciones en terrenos públicos hizo necesario la distribución entre agricultores interesados. Esto tuvo por resultado la concentración en algunas áreas de la isla donde luego muchas especies de eucalipto resultaron inadaptables. Los datos sobre las plantaciones anteriores a 1932 se perdieron debido al huracán que hubo ese año. Muy recientemente se ha empezado a acumular datos sobre pruebas sistemáticas hechas en ambientes estacionales prometedores.

Casi todas las plantaciones de eucalipto se han hecho a elevaciones menores de 500 pies en las costas o a elevaciones de 2.000 a 3.500 pies en las montañas. La mayor parte de las localidades en elevaciones bajas tienen un clima tropical húmedo con temperaturas entre 60º y 90ºF y una precipitación de 50 a 120 pulgadas anualmente. Por lo regular hay una precipitación de por lo menos 3 pulgadas durante los meses más secos, de febrero a abril. Los suelos son en general arcilla derivada de rocas volcánicas sedimentarias.

En las montañas el clima es sub-tropical y lluvioso con temperaturas entre 50º y 85ºF y una precipitación de 85 a 120 pulgadas anualmente. Los suelos varían de friables a arcilla ácida dura, casi siempre profundos y de origen volcánico.

Los estudios sobre residuos de las primeras plantaciones y los resultados de experimentaciones recientes llevan a un número de conclusiones sobre la adaptabilidad de estas especies de eucalipto en Puerto Rico. Las más importantes son como sigue:

1. Se aclimatan mejor en las montañas que en las costas. Juzgando por los informes sobre el alcance de estas especies, esto es probablemente reacción tanto a la temperatura como a la precipitación.
2. Donde las condiciones climáticas son satisfactorias estas especies se adaptan bien a suelos desgastados por cultivo excesivo.
3. Donde se han adaptado han sobrepasado grandemente en diámetro y en altura a casi todos los demás árboles nativos o exóticos.
4. Donde se adaptan producen árboles de mejor forma que la generalidad de las otras especies.
5. Ninguna de las especies con que se ha ensayado, aún bajo condiciones favorables, desarrolla un dosel suficientemente grande en 10 años para dominar la vegetación nativa, incluyendo yerbas, trepadoras y árboles.

Un resumen sobre la adaptabilidad de varias especies de eucalipto con las que se ha ensayado más extensamente aparece en el Décimotercer Informe Anual de la Estación de Experimentación Forestal Tropical en esta misma edición y no necesita repetición detallada aquí. Sólo se describirán algunas de las relaciones más favorables entre especie y ambiente estacional.

En altitudes bajas sólo tres especies, *alba, kirtoniana* y *umbellata* se han adaptado. En las montañas las bien adaptadas son *kirtoniana, resinifera* y *robusta; maculata* promete.

Otras especie con las que se han hecho muchas pruebas pero que no se han adaptado bien en ninguna parte incluyen *triantha, botryoides, citriodora, gummifera, globulus pilularis, propinqua* y *sideroxylon.* Algunas de estas producen algunos árboles buenos por acre, pero no forman rodales uniformes. Otras crecen lentamente. Varias podrían lograrse si las plantaciones no estuviesen limitadas a suelos degradados por cultivo.

Propagación

Las dos especies de eucalipto que más se siembran *robusta* y *kirtoniana* se consideran fáciles de propagar y establecer en medios estacionales apropiados. La propagación, tanto en la costa donde la temperatura media es de 78ºF y la precipitación de unas 70 pulgadas, como en la falda de las montañas a 500 pies de elevación con una temperatura media de 74ºF y precipitación de 120 pulgadas anualmente, ha demostrado que esta última es sitio más favorable. El crecimiento es más rápido y la mortalidad más baja. La descripción que sigue se refiere a los viveros en las faldas de montañas.

La semilla se siembra en lechos elevados de hormigón (Véase Ilus. 1). El suelo en estos lechos es una mezcla de partes iguales de arcilla lómica, cachaza y arena gruesa. Los lechos recién sembrados se protegen del mucho sol y fuertes lluvias con cobijas de metal corrugado. La siembra se hace a razón de una libra por cada 50 pies cuadrados. Como precaución contra el salcocho se trata el suelo antes de la siembra con formalina o sulfato de cobre y más tarde con la mezcla de Caldo Bordeles si es necesario. A pesar de ésto el salcocho es un problema y se están ensayando otros medios de control.

Esta clase de siembra produce un rodal de semillones muy densos. El rendimiento por libra fluctúa entre 6.000 y 15.000 semillones. Al cabo de 8 o 12 semanas en los semilleros miden de 2 a 4 pulgadas de altura (Véase ilus. 2). Entonces se trasplantan los semillones durante un período de 2 o 3 semanas, escogiendo los más grandes primero. El suelo se moja bien para poder extraer los semillones sin que sufran daño las raíces.

Los arbolitos se trasplantan a lechos de trasplantación algo altos (Véase ilus. 3) y se espacían de 3 por 6 pulgadas. La trasplantación se efectúa con un almocafre. Las pruebas con tablas de trasplante con estos diminutos arbolitos no han tenido éxito. Se pierde poco en el trasplante y rara vez se necesita rociar. A las 8 o 10 semanas de estar en los lechos de trasplantación el material tiene de 18 a 30 pulgadas de altura y ya se puede plantar.

Los árboles se trasplantan al campo con raiz limpia se espacían de 6 a 8 pies. La supervivencia fluctúa entre 75 y 90 por ciento. A pesar del crecimiento rápido del eucalipto, hay que desyerbar los arbolitos dos veces al año durante 2 o 3 años para liberarlos de la vegetación nativa. Toda la maleza dentro de 18 pulgadas del árbol deberá cortarse a ras de suelo. A los 2 años los árboles miden generalmente unos 2 pies más que el resto de la vegetación y no necesitan más atención excepto una ocasional limpieza de trepadoras.

El *Eucalyptus robusta* y *kirtoniana* en sitios favorables sufren de pocas enfermedades o insectos. El problema principal de la ordenación en este aspecto es la muerte de árboles aislados en el rodal mientras dura. Usualmente la mortalidad de este tipo va precedida de marchitez descendiente en las copas y algunas veces por la exudación de resina y por crecimiento de renuevos inservibles en la base del tronco. En algunos sitios este tipo de mortalidad mantiene el dosel tan abierto que prolonga el problema con las trepadoras y favorece un denso crecimiento de la vegetación nativa que invade la plantación.

Ordenación

En Puerto Rico hay menos de 2.000 acres sembrados de eucalipto. Las plantaciones son mayormente jóvenes y muchas son ensayos dispersos para adaptabilidad al ambiente estacional. Por eso no han aplicado técnicas de ordenación como las del Brasil. Sin

embargo, las observaciones hechas señalan algunas prácticas deseables.

En los mejores sitios se necesita el aclareo antes de los 10 años. El síntoma principal de esta necesidad es la reducción en altura y en tamaño de las copas. Nunca se desarrolla un dosel tan denso que indique la necesidad de aclareo, tampoco desaparece la vegetación herbácea bajo los árboles. El ritmo de crecimiento de los árboles del dosel superior declina gradualmente con el tamaño de copas y la cosecha de tallos subordinados se hace deseable por razones económicas.

La producción de los maderos más grandes para los cuales parece convenir el eucalipto, postes de energía eléctrica, necesita una rotación de 15 a 20 años. Durante esta rotación uno o dos clareos son aconsejables.

La reforestación artificial con eucalipto incluyendo desyerbos y remoción de trepadoras cuesta 20 jornales por acre, por consiguiente el desarrollo de métodos de regeneración natural es deseable. Las perspectivas en este particular no son muy brillantes porque los semillones naturales de eucalipto son raros y los renuevos de árboles de 10 pulgadas o más son débiles.

Crecimiento

No hay datos sobre la productividad del eucalipto en Puerto Rico excepto en término de promedios diametrales en plantaciones cuyas edades se conocen. Está en preparación una tabla volumétrica que indicará el volumen en pies cúbicos hasta distintos diámetros superiores.

No se conocen todavía las diferencias importantes que haya entre los ritmos de crecimiento de las diferentes especies adaptadas. En altitudes bajas, plantaciones de 8 años de *alba*, *kirtoniana* y *umbellata* fluctúan entre 3 y 9 pulgadas de d.a.p. y entre 40 y 75 pies de altura. En las montañas, plantaciones de 13 años de *kirtoniana* y *robusta* fluctúan entre 6 y 16 pulgadas de d.a.p. y entre 60 y 90 pies de altura; la primera es la más alta y la última la de mayor diámetro. Datos adicionales sobre crecimiento aparecen en el informe anual en esta misma edición.

Un resultado halagador de los estudios sobre crecimiento es que por lo menos bajo una condición el crecimiento rápido contínúa hasta gran altura. En una plantación de *robusta* de 24 años bien espaciada, en arcilla laterítica, a 2.000 pies de altitud, el ritmo de crecimiento diametral anual para 48 árboles durante los últimos 5 años fué de 0,31 pulgadas. Para 15 árboles de más de 12 pulgadas de d.a.p., fué 0,41 pulgadas. Un árbol de 16 pulgadas creció a un promedio de 0,82 pulgadas por año.

Utilización

Hasta ahora la utilización del eucalipto no ha sido problema en Puerto Rico. Los pocos árboles que han alcanzado gran tamaño se han usado para pilotes o para leña. Sin embargo, puede surgir el problema debido a que se está dedicando al eucalipto un área cada vez mayor y a que no existe localmente ningún uso tradicional para esta especie, ni medios para su preservación. Aquí se ha sembrado el eucalipto principalmente porque crece más ligero y más derecho en sitios pobres que ningún otro árbol. Se presume que en un área tan densamente poblada como Puerto Rico, con tan pocos recursos forestales, cualquier madera, con tal que sea uniforme y barata y obtenible en cantidades encontrará mercado. El desarrollo de tal mercado se necesita para proveer salida a la creciente producción y para servir de incentivo para que se plante más, particularmente en terrenos privados.

La madera de *robusta* y *kirtoniana* se alabea mucho cosa que restringe su utilización a pilotes, postes y posiblemente pasta de madera. La madera se pudre en el suelo. Los espeques sólo duran de 24 a 36 meses, casi el mismo tiempo que duran los de maderas nativas.

Las pruebas para tratamientos con preservativos han demostrado que con el método de baños calientes y fríos, una absorción de 6 a 8 libras de carbolineum (sales) por pie cúbico es posible. No se conoce todavía que durabilidad tendrían los espeques así tratados.

Robusta se ha usado recientemente para pilotaje bajo suelo. Pilotajes de hasta 50 pies de longitud han resultado tan satisfactorios en todo respecto como los de pino importado, y parecen soportar el encaje mejor. Este puede que resulte ser uno de los usos principales del eucalipto en Puerto Rico.

Conclusiones

De la comparación de las experiencias con el eucalipto en Sao Paulo y en Puerto Rico se desprende un número de observaciones. Los mayores conocimientos a mano en Sao Paulo hacen esta comparación particularmente beneficiosa para Puerto Rico. Las principales conclusiones quedan aquí apuntadas.

1. Menos especies se han adaptado en Puerto Rico que en Sao Paulo. Sin embargo las adaptadas en Puerto Rico están entre las mejores especies de Sao Paulo.
2. La investigación del eucalipto ha meramente empezado en Puerto Rico. Muchas especies se han descartado a base de muy pocas pruebas. Se debe sembrar más extensamente las mejores especies sin tomar en consideración previas experiencias. Mejores suelos debieran probarse pues bien podrían buenas especies de eucalipto competir en rendimiento con otras cosechas de cultivo. Las especies que merecen más plantarse son *alba*, *botryoides*, *camaldulensis*, *triantha* y *umbellata*.
3. Se debe dar más atención a especies, fuentes de semillas y selección en los viveros. Tanto en Sao Paulo como en Puerto Rico existen algunas especies híbridas; éstas deberan identificarse para proteger las fuentes de semilla de acuerdo con lo descubierto. Por ahora semillas para pruebas deben obtenerse de fuentes exteriores confiables. Deben probarse localmente los resultados de la selección de semillones uniformes en los viveros.
4. Las plantaciones de eucalipto hechas inmediatamente después del cultivo de cosechas como se hace en Sao Paulo y también durante el cultivo, se debieron probar para hacer la reforestación con estas especies más fácil y atractiva para el agricultor.
5. Experimentos de ordenación para determinar los resultados de distintos regímenes de corta y para explorar las posibilidades de reproducción con renuevos del tronco son necesarios para asegurar un rendimiento máximo.
6. Se deben desarrollar cosechas productivas del estrato inferior. La continua necesidad de desyerbo en Sao Paulo y la invasión de árboles nativos bajo las plantaciones en Puerto Rico, indican la posibilidad de una cosecha secundaria bajo los árboles. El banano y el cafeto merecen probarse.
7. Una planta local de preservación como la tiene Sao Paulo debe establecerse para facilitar el mercadeo del gran número de maderos que pronto habrá en las plantaciones. Se necesitan también estudios sobre las posibilidades de la pulpa con especies locales si se desea alcanzar la completa utilización de la madera.

APENDICE I

Especies de Eucalipto probadas por la Companhia Paulista

acaciaeformis
acervula Hook (syn. *ovata*)
affinis H. D. et J. H. M.
alba Reinw.
albens Miq.
x *algeriensis**
amplifolia Naudin.
andrewsi J. H. M.
angulosa
x *antipolitensis*
*baileyana** F. v. M.
bakeri
bicolor A. Cunn.

bosistoana F. v. M.
*botryoides** Smith
caleyi J. H. M.
*calophylla** R. Br.
*camaldulensis** *Dehnh.* (syn *rostrata*)
x *camaldulensis** x *resinifera**
cambageana J. H. M.
camphora
*capitellata** Smith
cinerea F. v. M.
*citriodora** Hook
*cladocalyx** F. v. M. (syn. *corynocalyx*)
coccifera Hook
conica H. D. et J. H. M.
consideniana J. H. M.
cornuta Labill.
dawsoni R. T. B.
dealbata
deanei J. H. M.
decipiens Endl.
decurva
diversicolor F. v. M.
divas Schauer
drummondi
dumosa (syns. *ovata* & *johnstoni*)
elaeophora F. v. M.
erythronema Turez.
*eximina** Schauer
exserta
falcata
fasciculosa F. v. M.
ficifolia F. v. M.
foecunda Schauer
globulus Labill.
gomphocephala F v. M.
*goniocalyx** F. v. M.
grandifolia
griffithsii J. H. M.
guilfoylei J. H. M.
*gummifera** (*Gaerth.*) Hookr.
*gunnii** Hook
haematoma DC.
hemiphloia F. v. M.
hybrida J. H. M.
incrassata Lab.
*kirtoniana** F. v. M. (*grandis**)
kirtoniana F. v. M. (syn. *patentinervis*)
laevopinea R. T. B.
lehmannii Preiss
leucoxylon F. v. M. (syn. *cracilipes*)
*linearis** A. Cunn.
*lidleyana** (syns. *andreana, numerosa*)
longifolia Link & Otto.
loxophleba Benth.
macarthuri H. D. et J. H. M.
macrocarpa Hook
macrorhyncha F. v. M.
*maculata** Hook
maculosa R. T. B.
*maideni**
marginata Smith
megacarpa F. v. M.
melanophloia F. v. M.
melliodora A. Cunn.
microcorys F. v. M.
microtheca F. v. M.
moorei J. H. M. (syn. *microphylla*)
morisii (*morrisii*)
muelleriana A. W. Howitt.
obliqua l'Herit
obtusiflora
*occidentalis** Endl.
ochrophloia F. v. M.
odorata Behr.
oleosa F. v. M.
*oranensis**
*paniculata** Smith
patens Benth.
pauciflora Sieb (syn. *coriacea*)
x *paulistana**
*pilularis** Smith
*piperita** Smith
planchoniana F. v. M.
platypus Hook (syn. *obcordata*)
polyanthemos Schauer
populifolia Hook
preissiana Schauer
*propinqua** Deane & Maiden
puverulenta Sims (syn. *pulvigera*)
*punctata** DC.
*racemosa** F. v. M. (syn. *creba*)
redunca Schauer
regnans F. v. M.
*resinifera** Smith
*robusta** Smith
*rubida** Deane & Maiden

* Especies que se han adaptado muy bien en Río Claro. Río Claro.
x - híbrida.

*rudis** Endl.
salicifolia (sol.) Cav. (syn. *amygdalina*)
*saligna** Smith
salmonophloia F. v. M.
salubris F. v. M.
*scabra** (syn. *eugenioides*)
sieberiana F. v. M.
*sideroplhloia** Benth.
sideroxylon A. Cunn.
*smithii** R. T. B.
stellulata Sieb.
stricta Sieb.
stuartiana F. v. M.
squamosa H. D. et J. H. M.
tetragona (syn *pleurocarpa*)
*umbellata** (syn *tereticornis*)
x *trabuti**
triantha Link (syn. *acmenioides*)
*umbra** R. T. Baker
uncinata Turez
urnigera Hook
*viminalis** Labill.
viridis (syn. *acacioides**)
woolsiana R. T. B.


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GULF OF MEXICO
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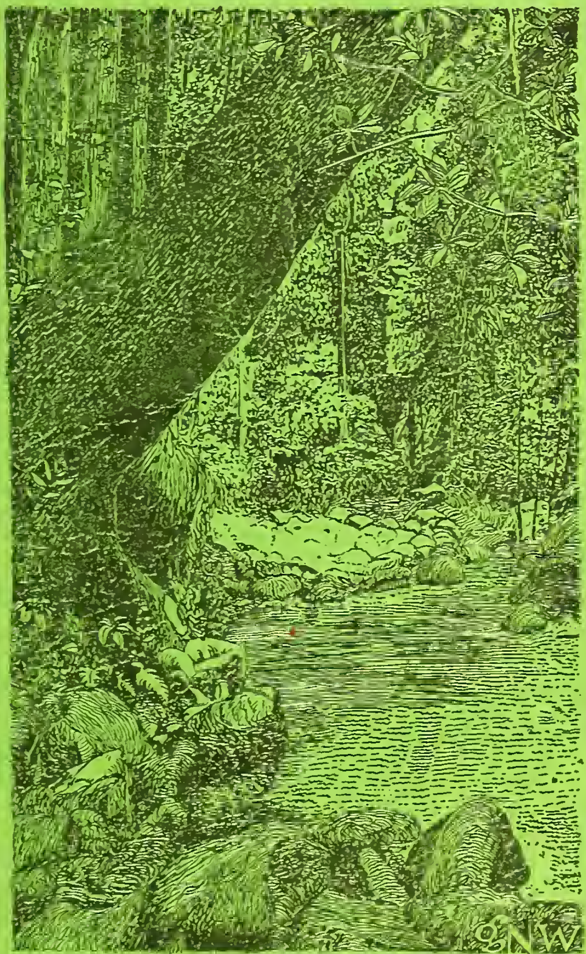

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
TROPICAL FOREST EXPERIMENT STATION
RIO PIEDRAS, PUERTO RICO

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Caribbean Forester

El "Caribbean Forester", revista que el Servicio Forestal del Departamento de Agricultura de los Estados Unidos comenzó a publicar trimestralmente en julio de 1938 es de distribución gratuita y está dedicada a encauzar la mejor ordenación de los recursos forestales de la región del Caribe. Su propósito es estrechar las relaciones que existen entre los científicos interesados en la Ciencia Forestal y ciencias afines encarándoles con los problemas confrontados, las políticas forestales vigentes y el trabajo que se viene haciendo para lograr ese objetivo técnico.

Se solicita aportaciones de no más de 20 páginas mecanografiadas. Deben ser sometidas en el lenguaje vernáculo del autor, con el título o posición que este ocupa. Es imprescindible incluir un resumen conciso del estudio efectuado. Los artículos deben ser dirigidos al "Director, Tropical Forest Experiment Station, Río Piedras, Puerto Rico."

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The "Caribbean Forester", published since July 1938 by the Forest Service, U. S. Department of Agriculture, is a free quarterly journal devoted to the encouragement of improved management of the forest resources of the Caribbean region by keeping students of forestry and allied sciences in touch with the specific problems faced, the policies in effect, and the work being done toward this end throughout the region.

Contributions of not more than 20 typewritten pages in length are solicited. They should be submitted in the author's native tongue, and should include the author's title or position and a short summary. Papers should be sent to the Director, Tropical Forest Experiment Station, Río Piedras, Puerto Rico.

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Le "Caribbean Forester", qui a été publié depuis Julliet 1938 par le Service Forestier du Département de l'Agriculture des Etats-Unis, est une revue trimestrielle gratuite, dediée a encourager l'aménagement rationnel des forêts de la region caraibe. Son but est d'entretenir des relations scientifiques entre ceux qui s'interéssent aux Sciences Forestières, ses problèmes et ses méthodes les plus récentes, ainsi qu'aux travaux effectués pour réaliser cet objectif d'amelioration technique.

On accept voluntiers des contributions ne dépassant pas 20 pages dactilographiées. Elles doivent ètre écrites dans la langue maternelle de l'auteur qui voudra bien préciser son titre ou sa position professionnelle et en les accompagnant d'un résumé de l'étude. Les articles doivent ètre addressés au Director, Tropical Forest Experiment Station, Río Piedras, Puerto Rico.

La revue laisse aux auteurs la responsibilité de leurs articles. La reproduction est permise si l'on présice l'origine.

"The printing of this publication has been approved by the Director of the Bureau of the Budget (August 26, 1953)

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The Caribbean Forester

Contents

Sumario

Frost Damage in the Pine Forest

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The winter of 1950-1951 in the Pine Forest of the Morne Des Commissaires region of Haiti was the most severe since regular recording of weather data was begun by the SHADA Forest Division in May, 1945. The direct result of exceptionally low temperatures was the killing of pine seedlings (*Pinus occidentalis* Sw.) and partial injury to pine saplings over relatively large areas. A consideration of the weather factors involved the type of injury, and the location and extent of the damage, leads to certain recommendations for forest practices to minimize future damage.

The Nature of Frost Injury

A summary of information concerning frost injury to forest trees is given here as a background for a better understanding of the situation in the Pine Forest. Trees suffer direct damage from frost. In warm regions lacking a regular annual cold period, the freezing of plant tissues usually results in death. Microscopical examination shows that the intercellular spaces normally filled with air contain ice crystals which were formed at the time of the freezing of the plant tissues and at the expense of the sap of the surrounding cells. This loss of water from the cells, together with the upset of the colloidal system, may be regarded as the cause of death. Death may also result when the very cold or frozen soil around the tree roots prevents the tree from absorbing adequate moisture to sustain the transpiration current. In addition to the direct action of cold in injuring delicate tissues, it is believed warm weather before freezing increases damage while cold temperatures lessen it. Also that rapid freezing or thawing furthers injury and repeated freezing and thawing is more harmful still. Moisture on the plant just before or during freezing augments the damage.

Frost injury can occur when the temperature falls below 32 degrees Fahrenheit, although experimental evidence indicates that it must drop at least several degrees below freezing before forest trees are affected. The frost-resisting power of trees has not been adequately studied. It is known that frost resistance is developed through natural selection, since frost-hardy races of some species exist. The point at which temperature becomes critically low varies widely, depending on the condition of the vegetation. Resistance is due chiefly to the inherent peculiarities of the protoplasm and to the admixture of sugar, oils, or resinous bodies with it. The amount of water present in the tissues of a tree plays a leading part; resistance in general being inversely proportional to water content. The succulent tissue of new growth, having a large amount of free water and dilute cell sap, may be severely injured at temperatures only a few degrees below freezing; whereas the older, lignified shoots may be uninjured.

Trees in the juvenile stage are much more subject to injury from cold than older trees. This is because in youth the roots and crown are near the ground surface, where the extremes in temperature are the greatest. Later in life, when the crown is farther above the ground, the roots are deeper in the soil, the tree is relatively safe. Trees growing in the shade are not injured as badly as those growing in direct sunlight. The protection afforded young trees by an overstory is to render temperature conditions more uniform and thus to raise the low extremes. Forest plantations established on grasslands suffer damage because the number and intensity of frosts immediately above ground is greater than elsewhere. In frost hollows or pockets, which are low areas in which cold air settles and cannot drain off, frost injury is severe and often prevents tree establishment.

Frost injury occurs in many forms. The most conspicuous is the discoloration, wilting,

and death of leaves and twigs. In conifers this takes the form of reddening or browning and death of needles with a characteristic curling downward of the twig or bunch of needles. Injury to the cambium is common. The entire cambium may be killed, thus girdling and killing the tree, or it may die in localized areas causing cankers, or if less severe, abnormal tissue will develop, resulting in a frost ring. Cambium damage is usually confined to young stems with thin bark. Bud development is influenced by frost, and in pine four different types of recovery have been classified: (a) bunched, (b) single leader, (c) double leader, and (d) multiple leader. Repeated killing of shoots leads to stunted and bushy trees with decreased growth.

Frost can cause splitting of tree trunks, when there is a sudden drop in temperature during which the outer wood becomes cold and contracts rapidly before the inner wood cools to an equal degree. The cracks usually originate at the base of the trunk, extend upward from a few to many feet; splitting the bark and penetrating deeply into the wood. Healing of the wood produces callous growth, repeated opening of the crack by cold or strains induced by wind will result in a very pronounced protruding callous growth, known as a frost rib.

Weather

The foregoing summary of frost injury indicates that air temperature is the significant, measurable factor causing frost damage to forest trees. The low temperatures at Pine Forest were recorded during the period from November to April, which includes the more or less dormant period for Haitian pine. Since this period is the dry season, but with diurnal temperatures high enough for plant growth, dormancy is considered a result of lack of sufficient moisture. It is presumed then that cold air currents coming into contact with pine foliage resulted in their freezing and subsequent death.

Table 1 summarizes weather data for the SHADA Forest Division headquarters site at elevation 5,500 feet.

Table 1. — **Minimum temperatures at Pine Forest**

Month	1945-46 to 1949-50 Ave.		Winter of 1950-51	
	Average	Minimum	Average	Minimum
	°F	°F	°F	°F
November	48.5	41.2	49.0	38.0
December	48.7	39.0	47.7	38.0
January	46.9	37.8	39.9	24.0
February	47.2	39.5	39.4	27.0
March	48.3	40.0	43.8	34.0
April	49.8	43.5	45.4	34.0

The minimum temperatures for the 1950-1951 winter may be regarded as exceptionally low when compared to the preceding 5 years. The critical temperature of 32°F was not recorded until 1949. The 1950-51 average winter minimum is a full 4 degrees below the previously established mean.

The Damage Observed

The low temperatures all occurred during the night and invariably the air temperature rose rapidly with daylight, as the days during this period were clear and dry. This caused a rapid thawing of frozen foliage which perhaps increased the amount of damage. In the early morning the pine needles exposed to the freezing temperatures were covered with frost. After several such exposures some of the individual fascicles or bunches of needles curved downward, the curved portion being at the point of attachment of the fascicle to the main branch. The individual needles remained normal in shape.

These curled fascicles, with others in their normal position, turned reddish brown in color after several days. Some of the drooping fascicles were not frozen sufficiently to

kill the needles and remained healthy and green. Seven months later the bulk of the killed foliage was still on the trees, having changed to a dull brown color.

Damage appears to be confined to the foliage and affected most severely the pine seedlings and small saplings up to 3 feet high. Seedlings under a good cover of larger trees were only rarely affected. Heaviest damage ocurred in frost pockets, in the open on flat terrain .and on the savannes, where in some places 90 percent of the seedlings were killed with practically all of the remaining 10 percent partially damaged.

Larger saplings and small poles, ranging from 1 to 7 inches in diameter, were heavily damaged on savannes, on open flat areas, and in frost pockets. Those under an overstory or larger trees were little damaged or not at all. The damage to this size class was also confined to the foliage; the leaders or top branches being the parts most frequently hit, especially in dense stands. However, in all stands individual trees could be found with any part of the foliage killed. On some areas up to 80 percent of the saplings were damaged with the percentage of trees totally killed ranging up to 20 percent.

The largest tree seen killed was approximately 35 feet in height. However, trees of more than 20 feet in height were rarely killed. Damage to large poles and merchantable trees consisted of the occasional killing of an exposed branch or twig, usually at the base of the crown.

Location of Damaged Stands

In the Spring of 1951 a survey was conducted to locate the damaged stands with a view to determining the areas involved. It quickly became apparent that damage did not occur on sloping ground where there exists no obstruction to the continued downward flow of cold air. Using this finding and a knowledge of the topography of the forest a survey could be made in a very short time. The areas covered were those reached by the road system in the forest supplemented by mule travel.

On Morne La Selle at all elevations dead tufts of needles were seen here and there on trees of all sizes. At 8,000 feet elevation the noticeable injury was confined to scattered trees of 4 feet or less in height. The severity of injury varied from total kill to dead branches or individual bunches of needles. Often only the leader was killed. Most of the trees totally killed were 1 and 2 year old seedlings located in low spots where little or no overstory existed. As few flat, low spots are present at this elevation little damage was found. The maximum damage was found between 5,000 and 6,000 feet elevation, where the large savannes appear: Pistache, Philippe, Acani, Boucan Pierre. Heavy damage was found on all of these. The total area subject to frost injury was found to be 800 acres. Of this total 350 acres were heavily damaged.

Effect on the Tree and Stand

Each individual tree needs as a minimum number of needles to maintain protosynthesis. Below this amount the tree cannot provide enough food to sustain life. Many trees only partially damaged will succumb for this reason. Others with enough living foliage remaining to sustain life, but with lowered resistance, will eventually die through the invasion of insects, fungi and viruses. Damaged trees surviving all this will grow, but at a much slower rate that formerly until a normal crown is again developed. Also, those trees with the leader killed will be deformed by having lateral branches curving upward to form the new leader or epicormic buds forming multiple leaders.

The resulting stand made up of such trees will for several years be growing at a subnormal rate and some of the growth will be put on by trees that at maturity will be of little or no value for lumber. A stand with most of the trees killed must be re-established naturally by the surrounding trees. Such an area has had 5, 10, or 20 years production destroyed.

One possible beneficial effect of the frost must be noted, even though of minor importance. In a few dense stands where the damage was not great, such damage as occurred has accomplished a natural thinning where too many stems existed for best growth to take place. The damaged trees have been given a handicap in the race for survival and will now survive for a time in the understory. Their presence here will force the neighboring dominant trees to shed their lower branches earlier in life than otherwise.

Logging and Frost Damage

Any logging, no matter how light, will expose the smaller trees to greater tempera ture changes, with a consequent increase in damage when the terrain is flat or depressed. The entire removal of the overstory will result in widespread damage, as may be seen in the areas both east and west of the Pine Forest headquarters site. Small trees were especially susceptible where patches of the overstory were harvested. The trees, accustomed to shade presumably were damaged easily. Seedlings established on old skidroads, even in dense stands, were damaged while the adjacent stand was untouched. On heavily logged areas where bracken fern has taken over the site, that portion of the tree above the top level or the fern was sometimes da maged but those portions beneath the fern were free of damage.

Recommendations

To attain the objectives of forest management, frost injury must be held to a minimum. The only practical means by which the forest manager can do this is through wise selection of harvesting methods. The manager must recognize that under certain conditions of weather definite areas within the forest are especially susceptible to frost injury. These areas must be delineated and so cut as to provide maximum protection to the young stands.

The ideal to strive for on the susceptible areas is a uniform overstory of the older age classes. In the majority of the stands an uneven-aged condition is present. Such stands should be cut on a selection basis. This consists of the removal of individual trees. A sufficient number of trees must be left to provide protection to the young stand underneath, but at the same time giving these trees enough space por proper development. Where even aged stands are now on the ground, under no circumstances should any large groups of trees be removed. For a working rule it may be said that any clearcut areas should be kept to 1 acre or less in extent. For areas deficient in the older age classes, the growing stock must be increased until the desired overstory is attained. Where unavoidable frost damage occurs, the damaged trees that are deformed may have to be removed at intervals to allow the better formed trees to gain dominance.

The open, flat areas called savannes are another matter. Most of these savannes are devoid of tree cover, but some have a good cover, Boucan Pierre being one. Frost may here be one of the main factors prohibiting the normal establishment of trees. If this is true, it is possible that a cover can be estab lished, but such an event would be a slow process, consisting of a gradual encroachment of the forest onto the savanne from all sides. Such a process would be a matter of generations, and therefore as little cutting as possible should take place on the savannes. The heavier the overstory left on the border the more protection will be given the seedlings moving onto the savanne.

No damaged areas are at this time in need of artificial reforestation. If damage occurs in the future, planting would be one possible means of bringing the area back into production with the least possible loss of time.

Ornamental Trees in Puerto Rico

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Although there are not always clear-cut distinctions an ornamental tree may be defined as any tree planted or left for decorative purposes. This would exclude trees planted purely for orchard, forestry, or windbreak purposes, although some of the same species might be used in another place as ornamental trees. Many trees which are considered desirable in one section are weeds in another. Ornamental trees need not bear conspicuous flowers. In fact, the most valued temperate climate species such as the maples, elms, and oaks have inconspicuous flowers. This is also true of many tropical trees.

For the Tropics and Subtropics a much wider range of tree species is available than in the Temperate zone. There is also much more variety in form if we include the palms and bamboos. A broad classification according to growth habit and form might be set up as follows:

1. **Palms.** — Some palms are too small to be classified as trees. The royal palm is a good example of a tree size palm.
2. **Bamboo.** — Grasses which grow to tree size usually with soft feathery foliage.
3. **Coniferous evergreen.** — Not so common in the tropics as in temper ate zones.
4. **Broad-leaved trees**
   a. Deciduous. — even in the tropics many trees shed their leaves and stand bare for periods varying from one week to several months. Some trees such as the roble amarillo (*Tabebuia glomerata* Urb. flower during this period.
   b. Evergreen. — leaf shed is gradual throughout the year. A good example is the indian laurel. (*Ficus nitida* Thum.)

The esthetic value of trees has been long recognized and they have figured prominently in the religious and folk ways of practically all peoples. Trees are larger, stronger, longer lived than man. The ancients workshiped them, performed ceremonies before them, and hung offerings on their trunks. Our own literature is rich in tree lore. The Bible speaks frequetly of trees, we read of "yule logs," we have our Christmas tree and Arbor Day ceremonies.

The landscape would be dreary without trees. The monotony of plains and deserts is broken by streams and oases where trees may be found. The predominant color of trees, green, is pleasing to the eye and the shade cast by trees is associated with coolness. In addition many trees are of value because of their flowers and few sights can equal that of a grove of flowering trees.

Trees may serve many useful purposes. In our cities we try to hide ugly sights by planting them. Here they may be planted along the streets for shade and to soften the outline of buildings. Our cities are also sprinkled with parks and plazas where trees are the predominant plants. When so planted trees give relief from summer sun and add to the recreational value of parks. Trees provide homes for birds and animals for which we have an attachment. Perhaps the greatest use of all is that trees are the most important components of the landscape and the principal tool of the landscape gardener. They give dimension and profile to the landscape.

In the landscape design all trees are ornamental but may serve a variety of purposes. The first of these is framing. Trees may

be used to frame the view of a dwelling or business building as it is presented to the public, i.e., the view from the road. Likewise, most landscape views may be improved by framing with trees. Framing focuses the vision upon the desired scene. Such a tree would be an unpruned Indian-laurel (*Ficus nitida*).

Trees may be grown to screen undesirable views of streets, factories, or neighboring buildings. For this purpose a densely foliaged tree which retains its foliage throughout the year would be most desirable. In Puerto Rico the "palo de maría" (*Calophyllum antillanum* Brit.) might be used. Trees are often planted to soften the architectural lines of a home or building rather than to screen it from view. In such a location the jacaranda (*Jacaranda acutifolia* H. & B.) might be utilized.

Often trees are used to accent the entrances to buildings or grounds and large trees as a background for the landscape picture. Another important use is to border walks and drives, for shade, an to outline the route. Trees will also mark property boundaries effectively because of their permanent nature .

Ornamental trees are especially well suited for specimen plants to be grown on lawns and near houses. In such locations choice of the subject is very important. Often a flowering tree is desired, but one should be careful to select a species which will not litter the ground continously with fallen flowers, seed pods, or leaves, and which will not grow quickly out of bounds or remain leafless for extended periods.

The following tree species have been selected because of their ornamental value in Puerto Rico. Not many of them are native to the island but some such as the flamboyant (*Delonix regia* Bojer) have been so widely planted that they are considered to be natives.

Tree Species Suited as Ornamentals

Palms

Scientific Name	Common Name	Remarks
Acrocomia media Cook	Puerto Rico Acrocomia Corozo	Large spiny palm, pinnate leaves
Areca catechu L.	Betel-nut palm Palma de areca	Large orange to red fruits
Arenga pinnata	Gomuti sugar palm Palma de azúcar	Very large pinnate leaves
Caryota urens L.	Toddy fishtail palm Palma de cola de pescado	Curious wedge-shaped leaflets
Chrysalidocarpus lutescens Wendl.	Golden-fruited palm Areca	Clumps of slender to sturdy trunks
Cocos nucifera L.	Coconut Coco	Falling nuts, dangerous
Dictyosperma album var. *rubrum* Wendl & Drude	Red palm	Graceful, pinnate leaves

Scientific Name	Common Name	Remarks
Euterpe Globosa Gaertn.	Mountain palm Palma de sierra	Feather palm native to higher mountains
Gaussia attenuata (Cook) Beccari	Puerto Rican llume palm Llume	Slender, small red fruits
Livistona chinensis R. Br.	Chinese fan palm Palma de borbón	Rather common, fan leaves
Phoenix canariensis Chabaud	Canary island date palm Dátiles de jardín	Large, pinnate leaves
Roystonea borinquena Cook	Puerto Rico royal palm Palma real puertorriqueña	Tall, stout
Sabal causiarum (Cook) Bec.	Puerto Rican hat palm Palma de sombrero	Stout trunk, fan leaved
Thrinax microcarpa Sarg.	Brittle thatch palm Palma de escoba	Slender, palmate
	Bamboos	
Bambusa multiplex	Hedge bamboo Bambú enano	Dense growing. Good for tall foliage
Bambusa tulda Roxb.	Tulda	Straight, stout culms, feathery hedges
Bambusa vulgaris Schrad	Common bamboo Bambu	Attractive feathery foliage
	Narrow-leaved Evergreens	
Araucaria excelsa R. Br.	Norfolk-island-pine Pino Norfolk	Fir like foliage Symetrical branching.
Cupressus spp.	Cypress ciprés	Much branched, formal looking.
Pinus spp.	Pines Pinos	Needle-like leaves
Podocarpus coriaceus L. C. Aich.	Yacca Podocarpus Caoba del país	Spreading branches
Thuja orientalis L.	Oriental Arborvitae Tuyas	Usually cone shaped trees.
	Broad-leaved Trees	
Adansonia digitata L.	Baobad	Stout trunk, white flowers
Adenanthera pavonina L.	Sandal beadtree Coralitos	Fern-like foliage
Albizzia lebbeck (L.) Benth.	Woman's tongue Lengua de mujer	Cream colored flowers

Scientific Name	Common Name	Remarks
Aleurites moluccana (L.) Willd.	Candlenut Nuez de la India	Cream colored flowers
Andira jamaicensis Urb	Cabbage Angelin tree Moca	Dense panicles of lavender flowers
Artocarpus altilis	Breadfruit Pana	Attractive foliage
Artocarpus heterophyllus	Jackfruit Jaca	Large fruits borne on main branches and trunk.
Bauhinia monandra Kurz	Napoleon's Plume Mariposa	Showy pink flowers
Bauhinia purpurea L.	Purple Bauhinia Palo de orquídeas	Large, showy flowers
Bauhinia variegata L.	Orchid tree Palo de orquídeas	Showy lavender flowers
Bixa orellena L.	Annato Achiote	Pink flowers, prickly fruit
Brassaia actinophylla	Australian umbrella-tree	Flowers in terminal red spikes
Byrsonima crassifolia (L.) H.B.K.	Byrsonima Maricao	Yellow flowers
Calophyllum antillanum Brit.	Calaba beautyleaf Palo de maría	Shiny, leathery leaves
Calycophyllum candidissimun	Degame	Lacy white flowers
Cananga odorata	Ylang-ylang Ilanilán	Extremely fragant flowers
Cassia fistula L.	Golden shower Cañafístula	Showy yellow flowers
Cassia grandis L. F.	Pinkshower Senna Caña-fístula cimarrona	Dark pink flowers
Cassia multijuga Rich.	Senna	Yellow flowers
Cassia nodosa Hamilt.	Jointwood Senna Acacia rosada	Showy rose-pink flowers
Cassia siamea Lam.	Bombay blackwood	Attractive yellow flowers
Cassia spectabilis (DC) Brit. & Rose	Calceolaria cassia Acacia amarilla	Yellow flowers
Casuarina equisetifolia Forst.	Australian pine Pino	Intersting branching, showy fruit
Cavanillesia platanifolia H.B.K.	Cuipo	Pink flowers, 5-winged capsule
Ceiba pentandra (L.) Gaertn.	Silk-cotton tree; Kapok, Ceiba	Large, tall, thorny

Scientific Name	Common Name	Remarks
Chrysobalanus icaco L.	Icaco; cocoplum Icaco	Glossy green foliage
Chrysophyllum cainito L.	Caimito starapple Caimito	Leaves shiny green above, copper brown beneath
Chrysophyllum oliviforme L.	Satinleaf starapple Caimitillo	Silver to brown-backed leaves
Cinnamomum cassia	Cassia-bark tree Canela cimarrona	Dense foliaged tree
Clusia rosea Jacq.	Pitch apple Cupey	Leathery leaves, attractive flowers
Coccolobis uvifera (L.) L.	Seagrape Uva de playa	Rounded, red-veined leaves, clusters of reddish fruits
Cochlospermum vitifolium Spreng.	Yellowsilk shellseed Rosa imperial	Showy yellow flowers
Cordia nitida Vahl.	Glossy cordia Capá colorada	Showy red fruits
Cordia sebestena L.	Geigertree cordia San Bartolomé	Orange flowers
Couroupita guianensis Aubl.	Cannonball tree Bala de cañón	Fruit has offensive odor
Crescentia cujete L.	Calabash tree Higuero	Large, hard-shelled fruits
Cybistax donnell-smithi	Primavera	Yellow flowers when leafless
Delonix regia (Bojer) Raf.	Royal poinciana Flamboyan	Showy scarlet flowers
Didymopanax morototoni (Aubl.) Dcne.	Matchwood Yagrumo macho	Leaves clustered at the ends of the branches
Dillenia indica L.	India Dillenia Dilenia	Large, white, magnolia-like flowers
Enterolobium cyclocarpum (Jacq.) Grisb.	Elephants Ear Oreja de mono	Becomes very large
Erythrina berteroana Urban	Dwarf coral tree Machete	Dwarf tree, coral flowers
Erythrina glauca Willd.	Coralbeam Bocayo	Flowers cream to orange
Erythrina poeppigiana (Walp.) O. F. Cook	Bucare Coralbeam Bucare	Orange scarlet flowers
Eucalyptus spp.	Eucalyptus Eucalipto	Usually sparse foliage

Scientific Name	Common Name	Remarks
Eugenia spp.	Eugenia Hoja menuda	Dense foliaged trees
Ficus benjamina L.	Benjamin Fig	Long, drooping branches orange to red fruits
Ficus elástica Roxb.	India-rubber-tree Palo de goma	Shiny, leathery oblong leaves
Ficus retusa	India laurel Fig Laurel de la India	Often trimmed to umbrella shape
Ficus sintenisii Warb.	Higuillo prieto	Becomes very large
Ficus stahlii Warb.	Jaguey	Very large, spreading
Gardenia jasminoides Ellis	Cape-jasmine Gardenia	Large, white, fragant flowers
Gliricidia sepium (Jacq.) Steud.	Madre Madre de cacao	Pale pink flowers
Grevillea robusta Cunn.	Silkoak Roble de seda	Fern-like foliage
Guaiacum officinale L.	Lignumvitae Guayacán	Blue flowers, yellow fruit
Guaicum sanctnum L.	Holywood Lignum vitae Guayacán	Branches spreading or pendulous. Blue flowers
Guarea trichilioides L.	American muskwood Guaraguao	Large evergreen tree
Haematoxylon campechianum L.	Logwood Campeche	Pale yellow flowers
Hernandia sonora L.	Mago	Black fruits with longitudinal groves
Hibiscus tiliaceus L.	Linden Hibiscus Emajagua	Flowers yellow to orange red
Ixora macrothyrsa	Malay Ixora Bola de nieve	Small white flowers in clusters
Jacaranda acutifolia H. & B.	Sharpleaf Jacaranda Flamboyán azul	Blue flowers
Jacaranda filicifolia	Fernleaf Jacaranda Jacaranda	Blue flowers
Kigelia pinnata DC.	Sausage-tree Arbol de salchichón	Curious hanging fruits
Lagerstroemia speciosa (L.) Pers.	Queen Crapemyrtle Reina de las flores	Lavender flowers
Lucuma multiflora A. DC.	Lucuma Jácana	Glossy foliage

Scientific Name	Common Name	Remarks
Magnolia grandiflora L.	Southern Magnolia Magnolia	Large, white, fragant flowers
Magnolia portoricensis Bello	Magnolia Acibar	Shiny leaves, showy flowers
Magnolia splendens Urban	Laurel sabino	Large tree, showy flowers
Mammea americana L.	Mamey	Shiny, leathery leaves Brownish fruits
Mangifera indica L.	Mango	New foliage usually red
Melaleuca leucadendron L.	Cajeput-tree Cajeputi	Exfoliating paper bark
Melaleuca genistifolia	Bottle-brush	Red flowers of the characteristic bottle-brush type
Melia azedcrach L.	Chinaberry Lilaila	Lavender flowers
Montezuma speciosissima Sessé & Moc.	Maga	Showy red flowers
Moringa oleifera Lam.	Horseradish-tree Ben	Fern-like leaves, white flowers
Ochroma lagopus Sw.	Balsa Guano	Large leaves and flowers
Pachira aquatica Aubl.	Guiana-chestnut Pachira	Flowers large and very showy
Parkinsonia aculeata L. Sp.	Jerusalem-thorn Palo de rayo	Green twigs, almost leafless
Peltophorum inerme (Roxb.) Naves	Sogabark Peltophorum Falmboyán amarillo	Attractive yellow flowers
Polygala cowellii Blake	Violet-tree Palo de tortuga	Very conspicuous purple flowers
Pimenta racemosa	Bayrum-tree Malagueta	Glossy green leaves
Pithecellobium dulce (Roxb.) Benth.	Manila tamarind Guamá americano	Drooping branchlets, red fruits
Plumeria alba L.	White frangipani Alheli blanco	Large foliage, white flowers
Plumeria rubra L.	Red Frangipani Alhelí rojo	Pink flowers
Posoqueria latifolia (Lam.) R. & S.	Panama Posoqueria Café de Panamá	Very fragant white flowers
Pterocarpus indicus Willd.	Burmacoast Padauk Palo de pollo	Numerous, small, yellow, fragant flowers

Scientific Name	Common Name	Remarks
Ravenala madagascariensis J. F. Gmelin	Travelers-tree Palma de viajero	Giant fan of leaves
Samanea saman Willd. & Merril	Raintree Dormilón	Large spreading tree
Sapindus saponaria L.	Soapberry Jaboncillo	Round, brown-skinned fruits
Sesbania grandiflora	Agati Sesbania Gallito	Large white or red edible flowers
Sideroxylon foetidissimum Jacq.	False mastic Tortugo amarillo	Flowers in clusters
Spathodea campanulata Beauv.	African tuliptree Tulipán	Large orange-scarlet flowers
Stenolobium stans Seem.	Florida yellowtrumpet	Clusters of yellow, slightly fragrant flowers
Sterculia apetala (Jacq.) Karst	Coolie Sterculia Anacaguita	Large spreading tree
Swietenia macrophylla King	Honduras mahogany Caoba de Honduras	Tall; dense foliage
Swietenia mahagoni Jacq.	West Indies Mahogany Caoba dominicana	Shiny, dark-green leaves
Syzygium cumini (L.) Skeels	Jambolan Yambolana	Clusters of small, black, edible fruits
Syzygium jambos	Roseapple Pomarrosa	Yellowish, roselike odor, edible fruits
Syzygium malaccense	Malayapple Pomarrosa americana	Deep-crimson, edible fruits
Tabebuia glomerata Urban	Trumpet-tree Roble amarillo	Yellow flowers when leafless
Tabebuia pallida Miers	Whitewood trumpet-tree Roble blanco	Pink shades
Tamarindus indica L.	Tamarind Tamarindo	Fine dense foliage
Tectona grandis L.	Teak Teca	Flowers in airy panicles
Terminalia catappa L.	Tropical almond Almendra	Red winter foliage
Thespesia populnea (L.) Soland	Seaside mahoe Emajaguilla	Yellow flowers
Triplaris americana L.	Longjohn ant-tree Triplaris	Cerise flowers

Scientific Name	Common Name	Remarks
Warscewiczia coccinea (Vahl.) Kl.	Orange-gold chaconia	Long vermilion sprays

Trees to be Avoided Especially for Planting near Dwellings

Scientific Name	Common Name	Remarks
Euphorbia cotinifolia	Euphorbia	Sap extremely irritating
Hura crepitans L.	Sandbox-tree Havilla	Sap extremely irritating
Hymenaea courbaril L.	Courbaril Algarrobo	Fruit stinks
Jatropha curcas L.	Barbados-nut Tártago	Fruit poisonous
Sterculia foetida L.	Hazel Sterculia Anacaguita	Flowers stink

New Observations of Tree Growth in Tabonuco Forest

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The tabonuco forest type constitutes the most important relic of natural vegetation in Puerto Rico. Although probably less than 1,000 acres remain in virgin condition, more than 25,000 acres of this type of forest still retain much of their original composition. These areas lie between 500 and 3,000 feet of elevation. The largest remaining blooks of forest are in the Sierra de Luquillo and the Sierra de Cayey.

The tabonuco type has been so named because of the prominence of the tabonuco tree (*Dacryodes excelsa* Vahl.) within it. In some virgin forests this species made up as much as 30 percent of the basal area and more than half of the timber volume. The type is classified as tropical moist forest by Holdridge (*3*) and as lower montane rain forest by Beard (*1*).

The importance of this forest type to Puerto Rico goes far beyond its benefits in producing timber and conserving soil and water on the 25,000 acres it now covers. It apparently is the climax vegetation on no less than one third of the land surface of the island. At least 300,000 acres within this zone, because of the need for protection of the soil, should always remain tree covered. Thus the results of investigations within the remaining small area of this type can serve as an indication of possibilities and a guide to practices on a very much larger area.

The tabonuco forest originally was probably the best developed in the island. Virgin stands on good sites range between 100 and 110 feet in height, and contain three tree strata. The upper stratum is not continuous but consists of emergent groups or individual trees with diameters ranging up to 6 feet. The second stratum, at 60 to 70 feet, produces a closed canopy, beneath which the less continuous third stratum is found. The forest is mixed, with 33 species on an average acre, and a total of about 175 species recorded for the type.

Past forestry investigations in the tabonuco type have been largely preliminary in nature. Outside Puerto Rico the type is limited to a few thousand acres in the Lesser Antilles, so no large fund of information about it is available from elsewhere. The ecological studies of Beard in the Lesser Antilles (*2*), however, have provided us with descriptions of the type which are so detailed that they are helpful in distinguishing primary from secondary forest in Puerto Rico. Descriptions of the type in Puerto Rico have also been published (*9*) as have reports on the first efforts to regenerate and manage the forest (*8*, *10*, *11*). Preliminary data on tree growth and volume increment have also appeared (*4*).

Past studies of growth within the tabonuco type have concerned both virgin and cutover forest. In the virgin forest, where great stand density may develop, and where increment tends to be offset by mortality, the diameter growth of individual trees was found to be slow, averaging about 0.09 inch per year for the entire stand (*7*). It was also shown that diameter growth rates of individual trees differ with their crown position, those which are dominant and codominant tending to grow 50 percent more rapidly than those which are intermediate or suppressed. Conservative openning up of such stands by partial cuttings has been found to increase average diameter growth 50 percent or more, even for those trees which remain in the same position in the canopy.

More recently studies of the relative growth of different species within the forest were made (*5*, *7*). Comparable average

growth rates derived for a number of species showed marked differences, but data have usually been inadequate to establish mathematical proof of the validity of these observed differences. By 1950 six years of growth records in a 1.8-acre plot had provided an adequate basis for such a comparison with intermediate trees of five prominent species. The data for four of these species, tabonuco (*Dacryodes excelsa* Vahl.), ausubo (*Manilkara bidentata* (A.DC.) Chev.) motillo (*Sloanea berteriana* Choisy), and masa (*Tetragastris balsamifera* (Sw.) Kuntze), showed no significant difference in growth rate from that of the stand as a whole or from each other. A fifth species, yagrumo hembra (*Cecropia peltata L.*) was growing somewhat more rapidly (5 percent significance) than the rest of the stand.

Repeated remeasurement of individual trees has shown clearly that despite these apparent similarities in growth rates, marked differences do exist in the growth rates of some individual trees within these groups, that is, among trees of the same species and position in the canopy. An attempt made in 1951 (*6*) to determine visible factors which were related to this growth variability was unsuccessful. Correlations with diameter of the trees, and the apparent vigor of their crowns were not close. A third factor, the degree of competition, as measured by the aggregate basal area of all trees within 25 feet, unexpectedly showed virtually no correlation with growth.

The Need for Additional Growth Information

The few past investigations of tree growth in the tabonuco type generally confirm relationships which were to be expected on the basis of widespread experience elsewhere. For instance, it was to be expected that virgin forest growth would be slow, that trees dominating the forest might grow more rapidly than those suppressed within it. On the other hand, these studies have contributed new knowledge in showing the order of magnitude of these relationships under local conditions. Moreover, past growth data, even when incomplete, have helped appraise the potential productivity of different trees as components of managed stands.

The measurement of the growth rates of trees is no isolated objective. The growth rate is one measure of the productivity of a tree, but, far more important, it reflects the aggregate productivity of that complex of factors which make up what we call site, or environment. A knowledge of this relative growth response to different environmental conditions is basic to silviculture, which in part is a process of finding and bringing together productive trees and productive environment.

More complete knowledge of tree growth response to different environments in the tabonuco forest has at least three important applications in Puerto Rico.

1. To show possible economic returns from forestry on the 150,000 acres of similar lands which are unsuited to other than tree crops yet are virtually iddle. This will serve as an incentive for the practice of forestry by the farmers who own this land.

2. To make possible the intensification of the management of the tabonuco forest type on public lands. The removal of overmature an mature trees, those of poor form, and inferior species, is already largely accomplished on accessible areas. Further improvement requires more critical appraisal of the potential growth rates of the trees remaining.

3. To point the way to better management of coffee shade forests, which cover nearly 200,000 acres and most of which are located within the tabonuco forest zone. The growth of the coffee shade trees, and possibly also that of the coffee itself, is influenced by the same environmental conditions that control forest tree productivity.

Additional studies of three growth, as related to environment, can point to the optimum productive stand density, the best tree

species, the maximum size of tree to produce, and the significance of minor soil and other environmental differences.

New Observations

The fact that diameter growth measurements of numerous trees within the tabonuco forest showed differences which were not clearly related to the more obvious characteristics of environment or of the trees themselves, and the fact that these growth differences were of an order of magnitude which would materially affect productivity pointed to a need for closer study of these trees.

A complete study of the environment of an adequate number of trees to provide final conclusions as to the importance of all environmental factors in tree growth within the forest is highly desirable. Because of the complicated and very long-term nature of such an investigation, it was decided as a preliminary to study in detail those trees which represent growth extremes, in order to determine whether new visible indexes of growth rates might be discovered. This was done with 199 trees in four permanent sample plots comprising an area of about 6 acres within both virgin and secondary tabonuco type forest in the Luquillo Mountains.

Trees of Unusually Rapid Growth

The study of factors related to unusually rapid growth was based upon those trees growing at a rate of 2 inches in diameter per decade in virgin forest and 3 inches in diameter per decade in cutover forest. A total of 152 trees qualified for this study. They make up the most rapid growing 5 percent of the trees in the plots.

A number of visible environmental factors were found related to this rapid growth. One outstanding exception is position in the canopy. A total of 95 trees, or 63 percent, are intermediate or suppressed trees. These rapid growing trees are not more dominant than the others. This finding bears out the previously discovered weak relationship between growth rates and position in the canopy.

A clear relationship with topography was evident. Two-thirds of these rapid growing trees are located on the brink of steep slopes, on ridges, or on steep upper slopes. Rapid growing trees of tabonuco, granadillo, yagrumo macho, palo de matos, masa, and laurel avispillo tend to be limited to this site. On the other hand, rapid growing trees of yagrumo hembra, guaba, guaraguao, motillo, ausubo, and manzanillo are limited to the concave lower slopes and valley bottoms. Trees which are off their preferred sites, even when other environmental factors appear favorable, are usually growing slowly. Differential drainage requirements appear to be the most probable explanation.

The effects of catastrophes, such as windfalls are reflected in the growth of many trees. One-seventh of the rapid growing trees are located within 10 feet of rotten stumps. Many of these are growing in an environment which otherwise does not appear favorable to rapid growth. The death of a nearby large tree evidently relieves the intense competition for nutrients to a degree that is reflected in the more rapid growth of adjacent trees for many years thereafter.

There is some evidence to indicate that trees growing in locations subject to an exceptionally heavy accumulation of litter are materially benefited. Seven of these fast growing trees are very heavily suppressed but are growing directly down the slope from large trees which drop so much litter that a layer 6 inches deep or more is constantly present.

Several characteristics of these trees themselves appear to indicate their rapid growth. A total of 108, or nearly three-fourths of those studied are of exceptionally good form, many with perfect boles almost to the terminal. This is one of the most uniform characteristics of rapid growing trees. The average diameter of these fast growing trees is 7.8 inches, or only about 1 inch larger than that for the stand as a whole. The range is wide, from 2 to 25 inches d.b.h. This group thus includes all sizes of trees.

Four species were much better represented in this group of rapid growing trees than the others. Whereas this group includes 5 percent of all trees, it includes 38 percent of the granadillo (*Buchenavia capitata* Vahl.) Eichl.) 20 percent of the yagrumo hembra (*Cecropia peltata L.*), 18 percent of the matos (*Ormosia krugii* Urban) and 14 percent of the yagrumo macho (*Didymopanax morototoni* (Aubl.) Dcne). These differences appear sufficiently large to indicate a more rapid average growth rate for these species.

One-third of the rapid growing trees had exceptional bark, usually very smooth and free of lichens or mosses. Rapid growing trees of palo de matos have porous bark. On tabonuco the bark is often a rosy tint. Although these bark characteristics are not found on all rapid growing trees they were never seen on those which are not growing rapidly.

Trees of Unexpectedly Slow Growth

The study of factors related to unexpectedly slow growth was based upon those trees (excluding palms and understory species) which appeared vigorous at the beginning of the period but are growing 0.6 inch in diameter per decade or less. This study was limited to 3 acres of virgin forest. Only 47 trees, or 2 percent of the total stand qualified for this study.

The study of slow-growing trees yielded less than that of rapid-growing trees because it was more difficult to judge as to which of many apparent adverse factors might be the most significant. The most constant adverse environmental factor affecting these slow growing trees is extreme suppression. Five out of every eight were so completely overtopped as to receive almost no direct sunlight at any time of the day.

Certain characteristics of the trees themselves are apparently typical of slow growth. Only 5, or one-eight of these trees are now vigorous in appearance. The large deep green leaves of many of these trees were originally thought to be a sign of vigor, but apparently they are only a response to shade, and mean that death is not imminent, but not necessarily that growth is rapid.

The average diameter of these trees, 4.5 inches, is 2 inches less than that for the stand as a whole. All are less than 16 inches in diameter. This bears out observations elsewhere that the slowest growing trees in a stand are generally small.

The inconsistencies between diameter growth and visible growing conditions led to a theory that possibly there was an error in using diameter growth as the sole index of tree increment. It was conceived that possibly diameter growth and height growth rates are not directly related. For example, rapid height growth might take place in response to an opening in the canopy at a time when no reserve was left for diameter growth. The few data collected in this study tend to reject this theory. Twelve of these slow-growing trees made during a 5-year period an annual average height growth of 5.8 feet, compared with an average of 19.7 feet for 43 trees growing at the rate of 1 inch or more in diameter per decade.

Other visible factors apparently related to slow growth are small or thin crowns, characteristic of 22 percent of the trees, and disease or accidents which affected the same proportion .

Additional Observations of Environmental Relations

The preferences of several species for either the ridges or the valleys is shown even more clearly in composition than in growth rates. The species which show strongest preference for the ridges are comparatively rare in the valleys, and vice versa. Even slight local concavity or convexity of the surface seems to have a profound effect upon the composition of the seedlings, saplings, and larger trees.

The effects of hurricanes and windfalls in the virgin forest were evident in many parts of the plots. Apparently several large trees in the area now within the plots were

blown over in either the 1928 or the 1932 hurricane. Many rotten stumps and logs lying parallel are still visible. Along these logs, in the area which must have been the opening created by the windfall, the stand now, some 20 years later, is still dominated by species such as camassey (*Miconia* sp.), yagrumo hembra (*Cecropia peltata* L.) and achiotillo, (*Alchornea latifolia* Sw.), all near the low end of the successional scale. The camasey and yagrumo, now about full size and subject to increasing competition from the sides, are growing slowly. Seedlings of more advanced species are only beginning to invade beneath them ,indicating the long period required for the restoration of a composition similar to that before the catastrophe.

The large trees are almost invariably located beside rock outcrops on the ridges. This fact leads to the belief that root anchorage in such rocks is a prerequisite to hurricane resistance.

The organic matter in rotten stumps and logs is apparently an important source of nutrients for the existing stand. Several rotten stumps which were opened were thoroughly penetrated by tree roots some of which had grown vertically upward for 3 feet to reach the tops of such stumps.

The buttresses of large trees of some species, such as motillo and granadillo, form on the upper side of the tree effective litter traps. The litter held by these buttresses may be more than a foot in depth. Active roots are abundant in such areas and some of these arise directly from the lower parts of the buttresses.

Conclusions

A few new relationships have been uncovered which serve as indicators of tree growth rates in the tabonuco forest. The most important of these may be described as follows:

1. Trees of any size or position in the canopy may be growing rapidly.
2. Several tree species show a clear preference for either moist or well drained sites within the forest and generally do not grow rapidly off these sites.
3. Trees of rapid growth usually are of excellent form, and have smooth boles and clean bark which is free of lichens and moss.
4. Unusually large deep green leaves generally are not an indicator of rapid growth of suppressed trees - such as they are for dominant trees.
5. Height growth tends to be most rapid in trees of rapid diameter growth, so the latter is probably a good index of total increment.

Probably the most significant single finding of this study is the discovery of strong microenvironmental preferences in many species, as is shown by separate study of the upper and lower slopes. More detailed study of this relationship might well lead to deliberate modification of the forest composition to conform with the site preference of each species within it. If the trees are produced only on their chosen sites within the forest, it may then prove possible to induce all trees to grow at a rapid rate, since it was shown here that trees of all sizes and positions in the canopy may grow rapidly under favorable conditions. The result could conceivably be a tripling of tree growth rates within this forest.

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Some Observations from the Eucalyptus Study Tour to Australia[1]

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The Eucalyptus Study Tour, sponsored by the Food and Agriculture Organization of the United Nations and the Commonwealth of Australia, occupied fully the months of September and October, 1952, and took the participants into all the states of Australia.

The genus *Eucalyptus* dominates all the principal forest and woodland formations of Australia, with the exception of the rain forests. The harvesting and conversion of forest products in Australia is likewise principally a matter of harvesting and converting eucalypt products. Therefore, a complete account of the forest resources and industries studied in the course of the tour would amount to a fairly complete survey of the forest situation in Australia. This is not the purpose of the present report, which will be limited to those species and procedures which may be of value in the forest economy of certain selected areas.

Ecology

Climate

Eucalyptus forests are restricted to three principal areas in Australia (*7*) all of which receive at least 30 inches of rainfall (*18*) annually. These areas are the southwest corner of Western Australia, Tasmania, and eastern Australia from the southeast tip of South Australia along the coast of Victoria, New South Wales and south and central Queensland. A fourth eucalyptus forest, in a region of less than 20 inches of rainfall, lies along the Murray River between Victoria and New South Wales. This forest depends on the almost annual flooding of the Murray River for the major part of its water supply, and is known as riverain forest, being composed entirely of one species, *E. camaldulensis* Dehn.

Within this forest area are wide climatic variations associated with latitude and altitude, but generally the climate is controlled by proximity to the coast. Variations in temperature are, therefore, rather minor. Few areas experience temperatures lower than 10ºF., and such temperatures are found only in parts of Tasmania and the Australian Alps in New South Wales. The significant variations are in amount, distribution

[1] Extracted from an official report on the Study Tour

and effectiveness ,of precipitation. The ex tremes in amount are 30 and 60 inches. Western Australia and parts of the forest area in South Australia and southwestern Victoria have winter rainfall. Most of the forest areas of eastern Australia have uniform rainfall (*9*). Only in central Queensland are eucalyptus forests found in a region of true summer rainfall. Effectiveness of precipitation is gauged in Australia by the ratio of precipitation to evaporation, and that rainfall which equals or exceeds one-third of the evaporation from a free water surface is considered effective (*14*). All of the eucalyptus forest area falls within the area in which 5 months per year have a P/E ratio in excess of 1/3 and all of the higher-grade commercial forests, with the exception of the Jarrah and Tuart forests of Western Australia, fall within the area in which there are 9 or more months annually with P/E greater than 1/3.

Soils

The soils of the eucalyptus forest area are podsols or podsolized (*14*). This classification caused some discussion on the part of some of the silviculturists from Europe, since the typical Australian podsols do not show the clearly developed horizons of the classical northern European and North American podsols. The litter and humus layers are often very slight or completely lacking in Australian podsol profiles, and the demarcation between the leached layer and the layer of deposition is seldom distinct.

Vegetation Types

Broadly described the eucalyptus forest, in the sense in which the term is used here, occurs in two formations, the dry sclerophyll forest and the wet sclerophyll forest (*14*) In Western Australia, the only wet sclerophyll forest is the Karri (*Eucalyptus diversicolor*) forest on the plateau of the extreme southwest. The finest forests of eastern Australia, mountain ash and the blackbutt-bloodwood-gum forests of New South Wales, are also classified as wet sclerophyll formations. In both formations, eucalypts generally are dominant, but are by no means the only woody plants. *Acacia, Casuarina,* tree ferns, and palms, as well as trees of Myrtaceous genera (related to *Eucalyptus*) such as *Tristania, Syncarpia, Angophora,* and *Melaleuca* are abundant in many of the eucalypt forests.

The Genus Eucalyptus

The genus Eucalyptus is found in Australia, Celebes, Moluccas, New Guinea, New Britain, New Ireland, Timor and the Phillippines. Although many genera of the Myrtaceae are found in New Zealand, eucalypts are not native there. The great majority of species of eucalyptus are extra-tropical, the greatest number —more than 300— being found in New South Wales. One rather ambitious work on the geographic distribution of the eucalypts has been commenced (*5*), and separate maps showing species distributions in Western Australia and Victoria have been published. Species distributions may generally be characterized as rather localized. Only two species are found in both Western and Eastern Australia. These are *E. camaldulensis* Dehn. and *E. transcontinentalis* Maiden.

Related to the distribution of species is their occurrence in the various forest formations. In general, although a region may contain a large number of eucalyptus species, a given forest stand rarely contains more than six or eight — usually fewer. This is true even in rather complex stands such as are found in northern New South Wales and Queensland where the complexity is largely due to admixture of rain forest species in the eucalypt forest.

Within eucalypt forests, plant succession is not particularly apparent; rather a large forested area is likely to be mosaic of fairly simple eucalypt associations, the composition of each apparently a function of localized soil and climatic conditions. In the moister areas of Victoria and Tasmania, however, one can see eucalypt forests being succeeded by rain forest.

The taxonomy of the genus is inherently difficult. The political, cultural and botanical history of Australia includes few features calculated to mitigate this difficulty. The extent of Australia, its sparse population and relatively underdeveloped transportation system, and the firm adherence to "states rights" by each of the states, have all rendered a comprehensive treatment of the genus difficult. The Critical Revision of Maiden was the last attempt. Blakely's "Key" (*3*) based on Maiden's work remains the only usable treatment of the genus as a whole. Blekely's Key sets forth a scheme of subgeneric relationship groupings, with sections and subsections based on anther characters and series and sub-series based on other reproductive and vegetative characters. To what extent Blakeley's scheme corresponds to phylogeny is difficult to determine. The smaller categories, such as sub-series, might well be equated to species by botanists less inclined to accord species rank to each variant type.

Nomenclature is no less a problem than taxonomy. One finds that numerous entities change their names as one pursues them across state boundaries. Though stable and uniform nomenclature is not particularly essential for taxonomic purposes, those concerned with utilization prefer intellectual exercises of a different sort, and have established a set of standard trade names, which often correspond to the "common" names (*6*). Common names are particularly confusing to the newcomer to Australia, since many of them appear to refer to totally unrelated northern hemisphere genera, such as ash, box ,apple, and gum. Western Australia is a welcome exception; its principal eucalypts have aboriginal or local epithets, such karri, jarrah, tuart, wandoo, marri, mallet, gimlet and tingle.

Utilization

An excellent illustrated account of eucalypt utilization has recently been published (*19*) by R. F. Turnbull of the Division of Forest Products, Commonwealth Scientific and Industrial Research Organization. Therefore, the present account will touch principally on those aspects of utilization of particular interest in the actual or potential eucalyptus growing regions of Sub-Tropical Mexico and the Caribbean.

Aside from the ornamental and protection applications of eucalyptus, the chief potential importance of this group for the area in question appears to be in the production of high-grade hardwood lumber. As a source of pulp, eucalypts appear at a disadvantage in competition with conifers because the eucalypts have relatively short fibers. Therefore, eucalypt pulps are customarily supplemented by conifer pulps, both domestic and imported, in Australian paper mills.

The utilization of eucalyptus for lumber is beset by two principal difficulties, both of which have long been familiar to mill operators. These difficulties are the growth stresses, common to all hardwoods (*10*), but most pronounced in young, rapidly-grown eucalypts ,and seasoning difficulties, particularly collapse. Tiemann early and clearly recognized these difficulties (*17*), and pointed out that unwisely chosen species and small young trees might account for much of the difficulty in seasoning California-grown eucalypts. A third cause of degrade in the timber of many Australian-grown eucalyptus is the presence of gum veins. Jacobs (*11*) has shown that this defect, which may be extremely serious in certain species and localities, is most frequently an indirect consequence of fire.

Research

It is not appropriate to attempt a review of the whole field of eucalyptus research in Australia. Some botanical, silvicultural, and utilization studies in progress may be of interest, however.

Botanical study proceeds along two lines. First, conventional taxonomic studies which result in name changes and rapid increase in the number of named entities. This tendency, annoying enough elsewhere, is particularly frustrating in Australia, where a number of botanists work more or less independently on the same genus. Recently, a number of workers, who appear to be more interested in exploring relationships than in naming each variant entity, have started to study the genus experimentally. Pryor (*16*) has started a program of openpollinated progeny testing of hybrid swarms and of controlled hybridization, working with the highland species of New South Wales and Victoria. Similar work is being done in Tasmania.

The development of a punched-card sorting field key to the genus, with a card for each of 638 named entities is one of the more interesting current studies. This is largely the work of Norman Hall of the Commonwealth Forestry and Timber Bureau. Several sets of this key were being tested by the various State forestry organizations during the tour, and early reactions were generally favorable.

Silvicultural studies of interest deal largely with techniques for improving the composition and quality of fire-damaged and improperly-logged stands and with growth studies. The latter are of particular interest in the warmer, uniform rainfall areas where ring formation is weak or is otherwise an unreliable criterion of age. Fire is a widely used silvicultural tool in many of the Australian forests. Sometimes its use appears to be not too discriminating, but many instances are quite instructive. Regeneration appears to be less of a problem in many eucalypt forests than in most North American forests. Often the control of regeneration is the problem, and thining studies are a prominent feature of Australian silvicultural research. Very little planting of eucalypts has been done in Australia, but a number of good small plantations may be seen in various parts of the country.

A conspicuous gap in biological research in the eucalypt forests is in entomology and pathology. In the foothill forests, insects take what appears to be a large toll in increment, while in many of the forests, termites and heart-rotting fungi destroy large volumes of high-grade timber. There appear to be a wide species differences in the extent of loss due to these causes.

The program of research in eucalypt utilization carried on by the Division of Forest Products of the Commonwealth Scientific and Industrial Research Organization at the Forest Products Laboratory in South Melbourne is quite broad. The staff includes a number of highly qualified people working on basic problems as well as a number who are making contributions of immediate applicability in industry.

One field of studies being conducted at the Laboratory deals with the relation between wood anatomy and properties. The complex inter-relations between growth stresses, brittle heart and reaction wood constitute one phase of this study. Studies of the structural basis for collapse during drying are under way. Relatively little study seems to be devoted to low-temperature seasoning techniques, such as solvent and aziotropic seasoning.

Recommended Species Trials

It would be unwise to recomend any eucalyptus species for use in any given area where these species have not already been cultivated. As California experience with *E. globulus* has shown, even successful growth does not guarantee the harvest of a useful product. All recommendations, therefore, are for tests of species. For the sake of conciseness, these recommendations are incorporated in Tables 1 and 2.

Recommendations for species tests in certain sub-tropical areas in Mexico and in the Caribbean region are based on rather slight personal acquaintance with these regions. Some of the recommendations are of a highly hypothetical nature, for example the

suggestion that *E. bosistoana* should be tried in subtropical Mexico. Most of the species listed were seen in the field by the writer. Species not seen, or briefly seen and indistinctly recollected include *alba, deglupta, gomphocephala, macarthuri,* and *torelliana.* In all cases however, personal notes and recollections have been backed up by reference to two principal sources (*2, 3*).

There are several omissions from these tables which will be immediately apparent to anyone familiar with eucalypts. These are *E. globulus* and *viminalis*, omitted because they are so well, and, in general, unfavorably, known in this country. There is also *E. citriodora,* well known as an ornamental and source of essential oils in California and elsewhere. *E. maideni* has been omitted as it is quite similar to *E. globulus*.. No doubt the writer's selections will be subject to many justified criticisms. Some of the species included may not seem of outstanding value. Some species were suggested not for any particular merits other than the possibility that they might form an acceptable type of vegetative cover in an area dominated by chaparral.

Tables 1 and 2 are intended only to serve as a basis for the studies which should precede programs of eucalyptus tests in the various regions discussed. To facilitate the use of Tables 1 and 2, Table 3, which lists more familiar synonyms and common names, has been compiled. Before actually proceeding with such tests, the individuals planning them would be well advised to familiarize themselves with the outcome of eucalyptus introductions in other regions of generally similar climate and economy. Table 4, based largely on reports submitted to F.A.O. by the participants in the tour gives a general impression of experience in the western hemisphere with eucalyptus. The species in this table are limited to those included in Tables 1 and 2. Successful survival, denoted by "S" in Table 4, obviously does not imply a successful introduction; a species which survives may grow slowly, have poor form, or yield products of little value in a given economy. Nevertheless, reference to Table 4 may be a useful starting point in evaluating various species as candidates for testing. Following this, the reports on which pertinent sections of Table 4 are based should be consulted.

A word of caution should be added concerning the identity of eucalyptus species mentioned in reports from countries where this genus is exotic. Identification of eucalypts is difficult, especially when materials is taken from young plants or in new environments and when the person making the identification is not generally familiar with eucalypts in their native habitats. A rather striking example of mis-identification appears in Zon and Briscoe's study of Eucalypts in Florida (*21*). In this publication, two excellent protographs, captioned *E. resinifera* show this species with strikingly smooth white bark. In fact, *E. resinifera* is most readily recognized by its "rough, reddish fibrous" bark, "persistent to the small branches" (*3*).

Table 1. — **Species recommended for testing in Tropical Caribbean**

(See page 118 for explanation of column headings)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			Wood properties					
					Durability			
Species	Locality from which to obtain seed	Tree form	Density	Strength	Heart	Sap	Coll. Susc.	Special properties, uses, etc.
alba	Timor, Papua, Java	M	—	—	—	—	—	
cloeziana	Qld.	L	62	B	2	R	Yes	Rapid growth, good form.
deglupta	Philippines	L	—	—	—	—	—	Extremely rapid growth.
grandis	Qld.	L	41	C	4	R	—	Rapid growth, rose-colored wood.
gummifera	Qld.	M	—	—	—	—	—	Slow growth, durable wood.
maculata	Qld.	L	63	A-B	2-3	H	—	Wood tough, used for tool handles.
microcorys	Qld.	L	62	A	1	M	—	Excellent for flooring; wood "greasy".
multiflora	Qld.	M	—	—	—	—	—	Grows in coastal sub-saline areas.
paniculata	Qld.	L	70	A	1	R	—	Grows is mod, dry areas. Wood strong.
pilularis	Qld.	L	56	B	2-3	R	—	Rapid growth, good form.
propinqua	Qld.	L	66	A	1	R	—	Wood strong, durable.
resinifera	Qld.	L	59	B	2-3	M	—	"Mahogany" type wood.
torelliana	No. Qld.	L	—	B	2-3	—	—	
saligna	So. Qld., or No. N. S. W.	L	52	B	3	M	Yes	Higher, drier sites. Rapid growth.
umbellata	Qld.	L	61	B	2	M	Yes	Durable wood, good form.

Table 2. — Species recomended for testing in Sub-tropical Mexico
(See page 118 for explanation of column headings)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			Wood properties					
					Durability			
Species	Locality from which to obtain seed	Tree form	Density	Strength	Heart	Sap.	Coll. Susc.	Special properties, uses, etc.
alba	Timor, Papua, Java	M	—	—	—	—	—	
bosistoana	N. S. W. table lands	L	69	A	1	R	—	Grain interlocked. Good form.
cloeziana	Qld.	L	62	B	2	R	—	Rapid growth, good form.
deglupta	Philippines	L	—	—	—	—	—	Extremely rapid growth.
diversicolor	W. A.	L	57	B	3	I	—	Excellent form.
gomphocephala	W. A.	L	64	A	1	—	—	Wood tough, does not corrode iron.
grandis	Qld.	L	41	C	4	R	—	Rapid growth, rose-colored wood.
gummifera	Qld.	M	—	—	—	—	—	Slow growth, durable wood.
macarthuri	N. S. W.	S	—	—	—	—	—	Foliage has high percent geranyl acetate.
macrorrhyncha	A. C. T.	S	55	B	2-3	—	Yes	Leaves contain 7-10 percent rutin.
maculata	Qld.	L	63	A-B	2-3	H	—	Wood tough, used for tool hadles.
marginata	W. A.	L	51	C	2	R	—	Highly-prized cabinet wood.
microcorys	Qld.	L	62	A	1	M	—	Excellent for flooring; wood "greasy".
paniculata	Qld.	L	70	A	1	R	—	Grows in mod. dry areas. Wood strong.
pilularis	Qld.	L	56	B	2-3	R	—	Rapid growth, good form.
propinqua	Qld.	L	66	A	1	R	—	Wood strong, durable.
resinifera	Qld.	M	59	B	2-3	M	—	"Mahogany" type wood.
saligna	So. Qld., or No. N. S. W.	L	52	B	3	M	Yes	Higher, drier sites. Rapid growth
torelliana	No. Qld.	L	—	B	2-3	—	—	
umbellata	Qld.	L	61	B	2	M	Yes	Durable wood — good form.
wandoo	W. A.	L	A	A	1	I	—	

Table 1 and 2 Column Headings and Footnotes

(1) Name as given in Blakeley (*3*). See Table 3 for synonymy and common names.

(2) Where several localities are noted, this implies that various origins should be tested. State abbreviations are:

N. S. W. — New South Wales
Vic. — Victoria
Tas. — Tasmania
Qld. — Queensland
W. A. — Western Australia
S. A. — South Australia
A. C. T. — Australian Capital Territory

(3) Based on personal notes and on (*2*, *3*).

(4) Density in lbs./cu. ft. at 12 percent moisture content. Data from Div. For Prod. CSIRO.

(5) Strength groupings are those adopted by the Div. For. Prod. CSIRO, as shown in the following tabulation:

Average Properties of Timbers in Four Strength Groups at 12 Percent Moisture Content

Group	Modulus of rupture lb./sq. in.	Modulus of elasticity lb./sq. in.	Crushing strength paralell to grain lb./sq. in.	Shear strength lb./sq. in.
A	24,000	3,000,000	12,000	2,500
B	20,000	2,600,000	10,000	1,900
C	16,000	2,200,000	8,000	1,600
D	12,000	1,900,000	6,000	1,100

(6) Resistance to heartwood decay and terminate attack. Class 1 should give 20 years' service as poles or ties. Class 4 is the least durable.

(7) Refers to susceptibility to attack by Lyctus beetles:

H = highly susceptible
M = moderately susceptible
R = rarely susceptible
I = immune

(8) Based on list of species in which pronounced collapse occur (*1*).

(9) Based on (*2*, *3*) and personal notes and observations.

Table 3. — **Synonymy and common names of eucalyptus discussed in this report**

Species	Most familiar synonym	Standard trade name 1/	Other common names
alba Reinw.	—	—	—
bosistoana F. v. M.	—	Coast grey box	—
cloeziana F. v. M.	—	Gympie messmate	—
deglupta Blume	*naudiniana* F.v M.	—	Mindanao gum
diversicolor F. v. M.	*colossea* F. v M.	Karri	—
gomphocephala DC	—	Tuart	—
grandis Maid.	—	Rose gum	Flooded gum
gummifera (Gaertn.) Hochr.	—	Red bloodwood	—
macarthuri Deane Maid	—	Camden wooly butt	—
macrorrhyncha F. v M.	—	Red stringybark	—
maculata Hook.	—	Spotted gum	—
marginata Sm.	—	Jarrah	—
microcorys F. v. M.	—	Tallowwood	—
multiflora Poir.	*robusta* Sm	Swamp mahogany	—
paniculata Sm.	*drepanophylla* F. v. M 2/	Grey ironbark	—
pilularis Sm.	—	Blackbutt	—
propinqua Deane & Maid.	—	Grey gum	—
resinifera Sm.	—	Red mahogany	—
saligna Sm.	—	Sydney blue gum	—
torelliana F. v. M.	*tereticornis* Sm.	Forest red gum	Cadagi Blue gum
umbellata (Gaertn.) Domin. Blakeley	*redunca* var. *elata* (Schau.) Benth.	Wandoo	—

1/ CSIRO. (1948) Nomenclature of Australian Timbers.
2/ Not strictly a synonym, but the name for a slightly dictinct Queensland form.

Table 4. — **Summary of successful outcomes of eucalypt introductions into the Western Hemisphere based on reports of four participants to F.A.O., except as noted.**

Species	Brazil 1/	Chile	Uruguay 2/
alba	S	—	—
diversicolor	S	S	—
gomphocephala	—	S	—
grandis	S	—	—
gummifera	S	—	—
macrorrhyncha	—	S	—
maculata	—	S	—
marginata	—	S	—
microcorys	—	S	—
multiflora	—	S	—
pilularis	—	S	—
resinifera	—	S	—
saligna	S	S	S
umbellata	S	S	S
wandoo	—	S	—

1/ Incomplete listing—for complete information see works of Novorro de Androde (13).
2 See Tuset (20).

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Akawaio Indian Plant Names

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The Akawaios are a branch of the Carib tribe of Amerindians related to the Macushis, Arekunas, Patamonas, and true Caribs. They speak a dialect of a language common to them all and can readily understand each other. A list of plant names for the Macushi, Arekuna, and Patamona branches particularly would be almost identical with the present akawaio list. The Carib list is somewhat different.

The akawaios migrated to British Guiana from the West Indian islands at some undefined period and passed along the coast rather than up the Orinoco River. They were unable to drive out the Arawaks who were settled immediately behind the coastal belt so passed through their territory and settled in the forest region behind.

At the present day they inhabit the Pakaraima plateau west of Ayanganna on the upper Mazaruni River and its tributaries the Kako and the Kukui. They may however, be found working on the gold and diamond fields and timber grants north and east of this territory as far north as Bartica at the junction of the Mazaruni and Essequibo Rivers .

The akawaios are, in common with other Amerindian tribes, of a retiring nature with short, thickset bodies and rather unattractive, coarse features. They are shorter and slighter in build than the true Caribs. They were, possibly still are, sly and underhand in their dealings with other Amerindian tribes. Like other Amerindians they have weak constitutions and usually die young.

The Pakaraima plateau is a region of flat, gently sloping or undulating plateau between 1,200 and 3,000 feet above sea level broken by flat-topped sandstone mountains which rise in bold escarpments from 3,500 feet to 7,000 feet. The plateau is formed by horizontally bedded sediments —sandstone, conglomerates, quartzites, and shales—

hundreds of feet thick intruded by dykes and sills of gabbro and dolerite. The sandstones, conglomerates, and quartzites produce an infertile coarse white sandy soil, the shales and the volcanic intrusives tropical red earths some of which are reasonably fertile.

Rainfall varies from 150 inches per annum on the north east escarpment face to perhaps 100 inches per annum on the borders with Venezuela and Brazil. As a result the area is largely forest covered and the few savannas appear to be natural and not fire induced. Savannas occur on the upper Mazaruni between the Karaurieng Creek and the mouth of the Kukui, between the Kamarang and the Kako Rivers near the Venezuelan border, between the Kako and the Kukui Rivers around Roraima and near the Venezuelan and Brazilian borders.

The forest belt consists largely of two main types —rain forest on the tropical red earths and dry evergreen forest on the coarse white sands. The rain forest is largely dominated by *Mora bukea* (*Moragonggrijpii*) with a few areas of Clump Wallaba (*Dycymbe altosonii*) forest. The Mora Bukea forest scarcely differs from its lowland counterpart except in composition. The Clump wallaba forest is typical of the plateau and only occurs in the lowlands as an invasive type. Dry evergreen forest is more varied from Wallaba (*Eperua*) forest hardly differing from its lowland counterpart through Suruwai (*Cunuria glabra*) forest apparently peculiar to the Pakaraimas to gallery forest along the edges of the rivers characterized by *Dimorphandra congestiflora*. Where the soils are too shallow to carry high forest, savanna woodland and scrub savanna occur. The savannas are of a moist type on very shallow soils overlying sandstone or conglomerate. They flood with very little rain and are wet throughout the rainy season. They are essentially bunch grass-sedge savannas with multitudes of tiny herbs and clumps of low shrubs characterized by *Cyrilla antillana*. These savannas are an extension of the Venezuelan Gran Sabana. Areas of sheet rock occupy square miles west of Ayanganna and carry a heathlike vegetation composed almost entirely of *Vellozia tubiflora*.

Outside the sandstone belt the rivers are fronged by swamp forest of *Macrolobium bifolium* in the upper reaches and by Mora forest in the lower reaches or where the alluvial flats are wider.

Many of the rapids in the smaller streams are almost chocked with dense masses of *Eriocaulon capillaris*.

The system of spelling is the same as that adopted for the Arawak Indian Plant Names published in The Caribbean Forester, Vol. 8, No. 3: pps. 165-180, July 1947.

Aia, *Lonchocarpus chrysophyllus* Kleinh.

Aiari. *Tephrosia toxicaria* (Sw.) Pers.

Aibia (k)

Aibia-warai. *Bejaria glauca* HBK

Aima-eno. *Chrysophyllum auratum* Miq.

Aipo. *Dipteryx odorata* (Aubl.) Willd.

Ajikerai. *Fagara* spp.

Akaikara. *Ananas* spp.
Aechmea spp.

Akiau. *Astrocaryum munbaca* Mart.

Akmon. *Achrouteria pomifera* Eyma

Aku. *Simaruba amara* Aubl.

Aku-morombo. *Couepia* spp.

Aku-paira

Aku-wako. *Silverballi* - general name

Aku-wenupo. *Cissampelos*

Akwoto. *Dimorphandra congestiflora* Sprague & Sandw.

Amario-krokai. *Mikania* spp.

Amonai. *Bactris oligloclada* Burret

Aneo. *Silverballi*

Anike. *Zeea mays* L.

Anonde. *Bixa orellana* L.

Apak. *Persea gratissima* Gaertn. f.

Apak- warai

Apang. *Anisophyllea*
Miconia spp.

Aporuma, *Satyra panurensis* Bth. & Hk. f.

Arabo, *Crescentia cujete* L.

Araira, *Duguetia decurrens* R. E. Fr.

Arakaka, *Vatairea guianensis* Aubl.

Arapipo *Anaxagorea* spp.

Arauin, *Tabebuia serratofolia* (Fahl) Nichols
Tabebuia capitata (Bur. & K. Schum.) Sandw.

Arauta-kwaiko, *Pouteria* sp.

Arawintrü, *Rheedia spp.*

Ara-ya, *Psidium guajava* L.

Arosa

Asare, *Bombax flaviflorum* Pulle

Ashik, *Pterocarpus* spp.

Aurosai, *Phytolacca icosandra* L.

Aurosaurai, *Alchorneopsis floribunda* (Bth.) Mull. Arg.

(Aurosai-warai)

Awai-emo, *Bonafousia undulata* A. DC.
Stemnadenia cerea Woodson

Awaparepu, *Vuyba* spp.

Awara, *Astrocaryum tucumoides* Drude

Awatakai, *Centrosema* spp.

Buke, *Maranta arundinacea* L.

Chiko-eno, *Miconia marginata* Tr.

Ekekewai, *Rollinia exsucca* (Dun.) A.DC.

Ekik, *Manihot utilissima* L.

Ekwai, *Mussaenda speciosa* Poir.

Epewo, *Pithecellobium* sp.

Epikirik, *Ormosia* spp.

Eriwi

Eriwi-yurai (Eriwiwarai) *Xylopia aromática* (Lamb.) Mart.

Ero *Anacardium occidentale* L.

Es-eno-poko, *Toulicia* spp.

Iba, *Musa sapientum L.*

Ikorik, *Liriosma*

Imbaima, *Bertholletia excelsa* HBK

Imbo, *Caryocar nuciferum* L.

Ireng *Ocotea canaliculata* (Rich.) Mez

Irik, *Licaria canella* (Meissn.) Kostern.

Irumai, *Ficus* spp.

Iruwai, *Mouriria* spp.

Ito, *Ternstroemia* spp.

Kaikai, *Panopsis sessilifolia* (Rich.) Sandw.

Kaikara, *Guadua*

Kaikushi-ramutun, *Cladonia rengifer*

Kairaimai, *Pithecellobium pedicellare* (DC.) Bth.

Kaishak, *Dicymbe jenmanii* Sandw.

Kaka, *Pradosia schomburgkiana* (DC) Cronquist

Kamang, *Cecropia angulata* I. W. Bailey

Kamarai, *Licaria camara* (Schomb.) Kostern.

Kamarupo, *Bactris trichospatha* Trail

Kambai (k) *Pteris aquilina* L.

Kambang, *Hemitelia* spp.

Kami (k), *Heteropsis jenmanii* Oliv.

Kamaratakang, *Cassia apoucouita* Aubl.

Kamasimo, *Xanthosoma*

Kamboto, *Dryopteris* spp.

Kamwo, *Byrsonima stipulacea* Juss.

Kanau, *Peltogyne* spp.

Kanawai, *Dimorphandra congestiflora* Sprague & Sandw.

Kangaro-mabon, *Mauritia aculeata* HBK

Kapai, *Alexa imperatricis* (Schomb.) Baill.

Kapaia. *Carica papaya* L.

Kapaichan. *Socratea exhorrhiza* (Mart.) Wendl.

Kapo. *Calophyllum lucidum* Bth.

Kapui-engo. *Bauhinia* spp.

Karai. *Unonopsis glaucopetala* R E Fr.

Karaikarai. *Conomorpha* spp.
Ouratea spp.

Karamik. *Micropholis melinoniana* Pierre

Karapai. *Carapa guianensis* Aubl.

Karapipo. *Sterculia pruriens* (Aubl.) Schum.

Kararapo. *Mimosa myriadena* Bth.

Karaweru. *Retiniphyllum schomburgkii* Bth.

Karibang

Karimora. *Talisia squarrosa* Radlk.

Karipo. *Couratari* sp. nov.

Kartapang. *Bactris*

Karte. *Guadua* sp.

Karuk. *Genipa americana* L.

Karukumang. *Ilex Jenmanii* Loes.

Karwasai. *Brocchinia reducta* Baker

Kasakoro. *Lagenaria vulgaris* Ser.

Katama. *Catostemma commune* Sandw.

Katuwai. *Doliocarpus*
Davilla
Tetracera

Kauwik. *Swartzia sprucei* Bth

Kauyama. *Cucurbita pepo* L.

Kawisi. *Aniba ovalifolia* Mez

Kayau-eno-mio *Cephaelis tomentosa* (Aubl.) Vahl.

Kinoto, *Sloanea*

Kirichak, *Pagamea guianensis* Aubl.

Kobare, *Peperomia* spp.

Komwa

Konopia. *Reancalmia* spp.

Konowai. *Bonnetia sessilis* Bth.

Koperek. *Cedrela odorata* L.

Koraiok. *Ananas sativus* Schult var.

Koreko. *Cecropia*.

Koroware eriko. *Chelonanthus chelonoides* (L. f.) Gilg.

Koshirik. *Ischnosiphon surinamensis* (Miq.) Koern.

Kosing. *Parkia nitida* Miq.

Kot *Ocotea rodiaei* (Schomb.) Mez

Koto, *Alexa imperatricis* (Schomb.) Baill.

Kotik. *Hymenolobium* spp.

Kotnare. *Manihot utilissima* L.

Kotokwa. *Gossypium barbadense* L.

Kotokwa-warai. *Weltheria americana* L.

Kotore. *Sacoglottis*

Kowo

Kriporsen. *Tapura guianensis* Aubl.

Kuama. *Bambusa vulgaris* Wendl.

Kukwi. *Peltogyne venosa* Bth.

Kumak. *Ceiba occidentalis* (L) Burkill

Kumarawa. *Strychnos* spp.

Kumatara. *Dolichos lablab* L.

Kume. *Lecythis davisii* Sandw.

Kume-warai. *Terminalia quintalata* Maguire

Kunali-mulai (Kunali-warai) *Casearia silvestris* Sw.

Kunami. *Clibadium* spp.

Kunawaru *Miconia* spp.

Kung-waia. *Oenocarpus bacaba* Mart.

Kupo. *Piper* spp.

Kurachikang. *Macralobium bifolium* (Aubl.) Pers.

Kuradana, *Musa paradisiaca* L.

Kurakai, *Arrabidaea chica* Verl.

Kurarema, *Peperomia* spp.

Kurashi-urupoe, *Hirtella* spp.

Kurubedan, *Eschweilera*

Kurumbenbeo, *Ormosia coutinhoi,* Ducke

Kusapo, *Croton matourensis* Aubl.

Kuwaka, *Xanthosoma*

Kwabanai, *Rapatea* spp.
Stegolepis spp.

Kwai (Kowai), *Mauritia flexuosa* L.

Kwari (Kowari), *Inga*

Kwaturu, *Eschweilera grata* Sandw.

Kwiawi, *Solanum paludosum* Moric.
Solanum rugosum Dun.

Kwikpai, *Pouteria* spp.

Kwina, *Sapium* spp.
Hevea spp.

Kwipari, *Loxopterygium sagotii* Hk. f.

Mai *Licania laxiflora* Fritsch

Maikwak-esere, *Andira grandistipula* Amsh.
Tabebuia

Maitakin, *Symphonia globulifera* L. f.

Mai-warai, *Licania* spp.
Parinari spp.

Makang, *Sandwithia guianensis* Lanj.

Makarin, *Tapirira guianensis* Aubl.

Makwaiyare

Man, *Clusia* spp.

Manare (Monare), *Ischnosiphon obliquus* (Rudge) Koern.

Manasara, (Palmaceae)

Manau *Qualea albiflora* Warm.
Qualea polychroma Stafl.

Mangoro, *Rhizophora* mangle L.

Mapuru (Maporo), *Gynerium sagittatum* (Aubl.) Beauv.

Maranyo, *Copaifera*

Marbuk, *Iryanthera* spp.

Maripa, *Maximiliana regia* Mart.

Marsupai, *Pouteria* spp.

Maruk-ewan-tepu, *Eperua jenmanii* Oliv.

Masai, *Inga lateriflora* Miq.

Masapre

Masawi, *Pausandra martinii* Baill.

Matak, *Silverballi* sp.

Maumau, *Bombax aquaticum* (Aubl.) Schum.

Mekuru, *Musa sapientum* L.

Meniya, *Euterpe*

Mirikawai

Mo, *Peltogyne venosa* Bth. var.

Moniki, *Trema micranthum* (L) Blume

Mope (Mopa), *Arachis hypogaea* L.

Mope, *Cyperus rotundus* L.

Mope, *Spondias*

More, *Byrsonima incarnata* Sandw. var.

Morino

Moro, *Humiria floribunda* Mart.

Morombaurai (Morombo-warai) *Moronobea jermanii* Engl.

Morombo

Moro-warai, *Ouratea* spp.

Mosai, *Monotagma parkerii* (Roscoe) Schum.

Mosok, *Cassia pteridophylla* Sandw.

Mukruk, *Solanum*

Muruk, *Quiina guianensis* Aubl.

Mutuwari, *Clathorotropis macrocarpa* Ducke

Nak *Xanthosoma sagittifolium* (L) Schott.

Napo, *Hieronyma oblonga* (Tul.) Mull. Arg.

Napui, *Dioscorea*

Nosodomai, *Miconia* spp.

Nutsak, *Swartzia,* Blackheart

Ojipipo, *Duguetia yeshidan* Sandw.

Okoro, *Sloanea guianensis* (Aubl.) Bth.

Okoromai, *Eschweilera alata* ACSm.

Ombang, *Duroia eriopila* L. f.

Ore, (Sterculiaceae)

Orükorong, *Pithecellobium jupumba* (Willd.) Urb.
Pithecellobium corymbosum (Rich.) Bth.

Osowai, *Guatteria* spp.

Otoshimik, *Pterocarpus* spp.

Paira, *Piratinera guianensis* Aubl.

Paiwatopo, *Emmotum fagifolium* Desv.

Pakarunda, *Dalbergia*

Pakira-wenupo, *Inga*

Pakorai (Myrtaceae)

Panamwi, *Trichilia schomburgkii* C. DC.

Panatoro, *Parinari* spp.

Pandara, *Aniba kapplerii* Mez.
Ocotea schomburgkiana (Nees) Bth. & Hk. f.

Parakwai, *Mora gonggrijpii* (Kleinh.) Sandw.

Parakwaurai (Parakwaiwarai), *Matayba*

Paramana, *Chaetocarpus*

Parawakashi, *Pentaclethra macroloba* (Willd.) Kze.

Pareyu, *Silverballi*

Parupa, *Hortia regia* Sandw.

Paruruwaka, *Neea* spp.

Paruwe, *Dicymbe corymbosa* Bth.

Pasai, *Jacaranda copaia* (Aubl.) D. Don.

Patawaia, *Jessenia bataua* (Mart.) Burret

Patia, *Citrullus vulgaris* Schrad.

Paui-eno, *Pouteria cladantha* Sandw.

Paui-semu, *Aristolochia daemoninoxia* Masters.

Pembutu, *Cephaelis violacea,* (Aubl) Sw.

Petakorok, *Diospyros,* spp.

Piaima-pomo, *Cordia nodosa* Lam.

Piat, *Amanoa guianensis* Aubl.

Pio, *Duguetia yeshidan* Sandw.

Piriwo, *Marantea guianensis* Aubl.

Pokerewe, *Heliconia* spp.

Poko, *Eschweilera sagotiana* Miers
Eschweilera odora (Poepp.) Miers

Pomo, *Capsicum frutescens*

Ponai, *Didymopanax morototoni* (Aubl.) Dcne & Pl.

Ponjik, *Rhynchanthera* spp.

Popo

Porek, *Pouteria* spp.

Porekai (Poredai) *Aspidosperma excelsum* Bth.
Aspidosperma oblongum A.DC.

Poro, *Inga nobilis* Willd.

Powa

Pratakik, *Pourouma guianensis* Aubl.

Purue, *Manilkara bidentata* (A.DC.) Chev.

Rek, *Eriocaulon capillaris* Bong.

Reko, *Himatanthus* spp.

Remona, *Citrus medica* L. var. *acida*

Sak, *Ipomoea batatas* Lam.

Sakarai

Sakau, *Miconia* spp.

Samalung, *Pouteria* spp

Saparau, *Myrciaria vismeifolia* (Bth.) Berg.

Sara, *Scleria* spp.

Sarakang, *Bromelia karatas* L.

Sararai, *Cecropia juranyiana* Alad. Richt.

Sekerende, *Musa sapientum* L. var.

Sengwede, *Colocasia esculenta* Schott.

Seregwe, *Palicourea* spp.

Sha (k) *Byrsonima aerugo* Sagot

Shakari, *Bellucia* spp.

Shiba, (Caesalpiniaceae)

Shimaila, *Cespedesia amazonica* Huber

Shimi, *Terminalia* spp.
Buchenavia spp.

Shimiri, *Hymenaea courbaril* L.

Shipok, *Dioscorea* spp.

Shipotai, *Smilax* spp.

Shirimo, *Piptadenia suaveolens* Miq.
Mimosa

Shiroda, *Saxofridericia regalis* Rich Schomb.
Spathanthus unilateralis (Rudge) Desv.

Sikaru, *Saccharum officinarum* L.

Simana, *Catostemma altsonii* Sandw.

Suruwai, *Cunuria glabra* R. E. Schultes

Suruwa-pari, *Cunuria*

Takuna, *Yuyba* spp.

Takapia, *Geonoma* spp.

Takariwa, *Hernandia sonora* L.

Tamaren, *Maieta* spp.
Leandra spp
Tococa spp.

Tamu, *Nicotiana*

Tangwaiyang (Tamwaiya), *Anthurium nobile*, Engl.

Tashi, *Tachigalia* spp.

Tatang, *Aldina insignis* (Bth.) Engl.

Tekereu, *Sterculia rugosa* R. Br.

Tekureng, *Pouteria* spp.

Tensing, *Licania heteromorpha* Bth. var.

Tira, *Clathrotropis paradoxa* Sandw.

To, *Coutoubea ramosa* Aubl.

Tokwit-nanko, *Notopora schomburgkii* Hk.

Toro, *Mora excelsa* Bth.

Tumoreng, *Sclerolobium* spp.

Tun, *Aspidosperma sandwithianum* Mfg.

Tuwo, (Moraceae)

Uramik, *Wulffia baccata* (L.f.) Ktze

Urapa, *Piratinera guianensis* Aubl.

Urari, *Strychnos* spp.

Urumak, *Clusia* spp.

Urumaropo, *Licania mollis* Bth.

Uruwe, *Panicum* spp.

Usariwara-yauku, *Vriesia splendens* (Brongn.) Lem.

Ute

Wai, *Ocotea guianensis* Aubl.

Wai, *Lagenaria vulgaris* Ser.

Waiabilo, *Desmoncus* spp.

Waiawa, *Trattinickia* spp.

Waiking, *Poecilandra*

Waiking-pomo, *Cyrilla antillana* Michx.

Waila

Waila-miru, *Silverballi*

Waila-warai, *Silverballi*

Waila-wok· *Inga splendens* Willd.

Waimasayare, *Philodendron*

Wakawipa, *Micropholis melinoniana* Pierre

Wakukwapai, *Cephaelis altsonii* Sandw.

Wakwama, *Carludovica sarmentosa* Sagot

Wakwamik, *Tovomita* spp.
Clusia jermanii Engl.
Clusia fockeana Miq. etc.

Walama, *Vismia* spp.

Wambitona

Wana, *Apeiba echinata* Gaertn.

Wananai, *Ravenala guianensis* Steud.

Wanauboma, *Andropogon citratum* Hort ex DC.

Waramia, *Geonoma* spp.

Waranaku, *Couratari pulchra* Sandw.

Warapari, *Sclerolobium* spp.

Warayu, *Psychotria*

Wargo, *Caryocar*

Wariki, *Couepia exflexa* Fanshawe & Maguire

Warkamicho, *Quiina indigofera*, Sandw.

Warobai, *Xanthosoma*

Warumai, *Henriettea multiflora* Naud.

Waruwa, *Protium* spp.

Wasang, *Cordia exaltata* var. *melanoneura* Johnston

Wasewia (Wasia), *Euterpe edulis* Mart.

Watopari (Watopate), *Pera bicolor* (Kl.) Mull. Arg.

Watuwai, *Laetia procera* (Poepp. & Endl.) Eichl.

We, *Virola surinamensis* (Rol.) Warb.

Weruwe, *Palicourea guianensis* Aubl.

Wopa, *Eperua falcata*, Aubl.

Wütük, *Marlierea schomburgkiana* Berg

Yarak, *Graffenrieda ovalifolia* Naud.
Miconia spp.

Yorong, *Pradosia*

The Forests of Darien, Panama[1]

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The forests of Panama are one of the country's most important natural resources. Mr. R. D. Garver of the U. S. Forest Service in his report proposing a "National Survey of the Forest Resources of the Republic of Panama" estimated that the forested area of Panama amounts to 5,000,000 hectares, or 70 percent of the total land area of the Republic. However, it is estimated that such factors as inaccessibility and poor forest growth limit the total commercial forest area to 3,500,000 hectares. The bulk of the commercial forests of Panama are in the Provinces of Bocas del Toro and Darien. The forests of Darien cover an area of approximately 1,522,000 hectares.

FOREST TYPES

The forests below an elevation of 500 meters on the Pacific slope of the Cordillera that divides Panama, are Tropical Dry Forest. The mean annual rainfall of this area is less than 2,000 mm. distributed over eight months of the year, from May to December. A dry season from January through April limits the composition of the forest to drought-resistant species. In certain areas where edaphic conditions modify the effect of the weather specialized types of forest appear.

Upland Forest

The bulk of the forests of Darien belong to this forest type. However, no surveys have been made upon which to base area estimates. The composition of this forest is very complex, being made up of a great many species of trees, of which few have at the present time a commercial value. The general character of this forest is similar throughout the type but the distribution of individual species varies considerably from one section to another.

So far as is known to the writer, no detailed botanical studies have been made of this type of forest in Panama. General observations of forest composition show the following important forest trees in their approximate descending order of abundance.

Quipo (*Cavanillesia platanifolia*) (H. & B.) H.B.K.)

Espave (*Anacardium excelsum*)

Cedro espino (*Bombacopsis quinatum*)

Bongo (*Ceiba pentandra*) (L.) Gaertn)

Caoba or mahogany (*Swietenia macrophylla* King)

Cedro amargo (*Cedrela mexicana* L.)

Cedro cibolla (*Cedrela* sp.)

Tachuela (*Zanthoxylum* sp.)

Nazareno (*Peltogyne purpurea*)

Roble (*Tabebuia penthaphylla*)

Higueron (*Ficus* sp.)

Caucho (*Castilla elastica* Cerv.)

María (*Calophyllum brasilense*)

Mahogany

The most important timber tree of Panama is mahogany. The natural distribution of this species in the forest of the Pacific side of Panama extends from Costa Rica to Colombia. However, the tree is not distributed uniformly over this area. In many places it has been completely eliminated by logging or clearing for agriculture. The average stocking of commercial sized mahogany trees in the forests where found is less than one tree to the hectare. Isolated instances are

1/ The writer spent approximately 2 years, from 1951 to 1953, studying the forest of Darien for the Panama Forest Products Company, developing log supply sources and determining the volume of timber available.

reported of groups of 35 to 50 mahogany trees to the hectare, but these occurrences are rare.

The distribution of the remaining stands of mahogany in Darien extends from the area drained by the upper Rio Congo eastward to the Río Cucunati and Rio Sabana including the headwaters of the Rio Bayano in the Province of Panama, then southward along the tributaries of the Rio Chucunaque to the headwaters of the Rio Tuira on the Colombian border and then westward to the headwaters of the Rio Balsas and the sea coast and then northward between Cerro Sapo and the sea coast to Garachine Point (See map.)

Mahogany is not evenly distributed througout this area. Areas that support enough trees to justify logging operations alternate with areas that have no mahogany. The organization of mechanical logging operations requires careful field work to locate commercial stands.

It is estimated on the basis of field studies that the net volume of mahogany remaining in the area described is approximately 60,000,000 board feet. Based on limited observations in other areas of Panama it is estimated that the total net volume of mahogany existing in the entire country is 75,000,000 board feet. When deductions are made for trees too widely scattered to be logged economically and timber that is inaccessible, the net volume available to log is approximately 60,000,000 board feet for all of Panama, of which 50,000,000 board feet are located in Darien.

Espave

Espave is one of the most abundant trees in the upland forests. It is concentrated in moist, well drained river valleys and on gentle slopes. Locations where heavy stocking of espave was seen in Darien are in the Seteganti, Sambu, and Iglesias valleys. Volumes up to 25,000 board feet per hectare were found and the valley of the Seteganti was estimated to contain 8,000,000 board feet of espave.

Quipo

Quipo is the most abundant tree in the upland forests of Darien. It grows to large sizes, 2 meters in diameter and 20 meters to the first branch. Volumes as high as 50,000 board feet to the hectare have been observed.

At present there is no industrial outlet for this soft balsa-like wood. During World War II certain quantities were shipped to England as a substitute for balsa in the production of life-jackets and life-rafts. It is possible that in the future some industrial use for quipo wood will be found.

Lowland Forest

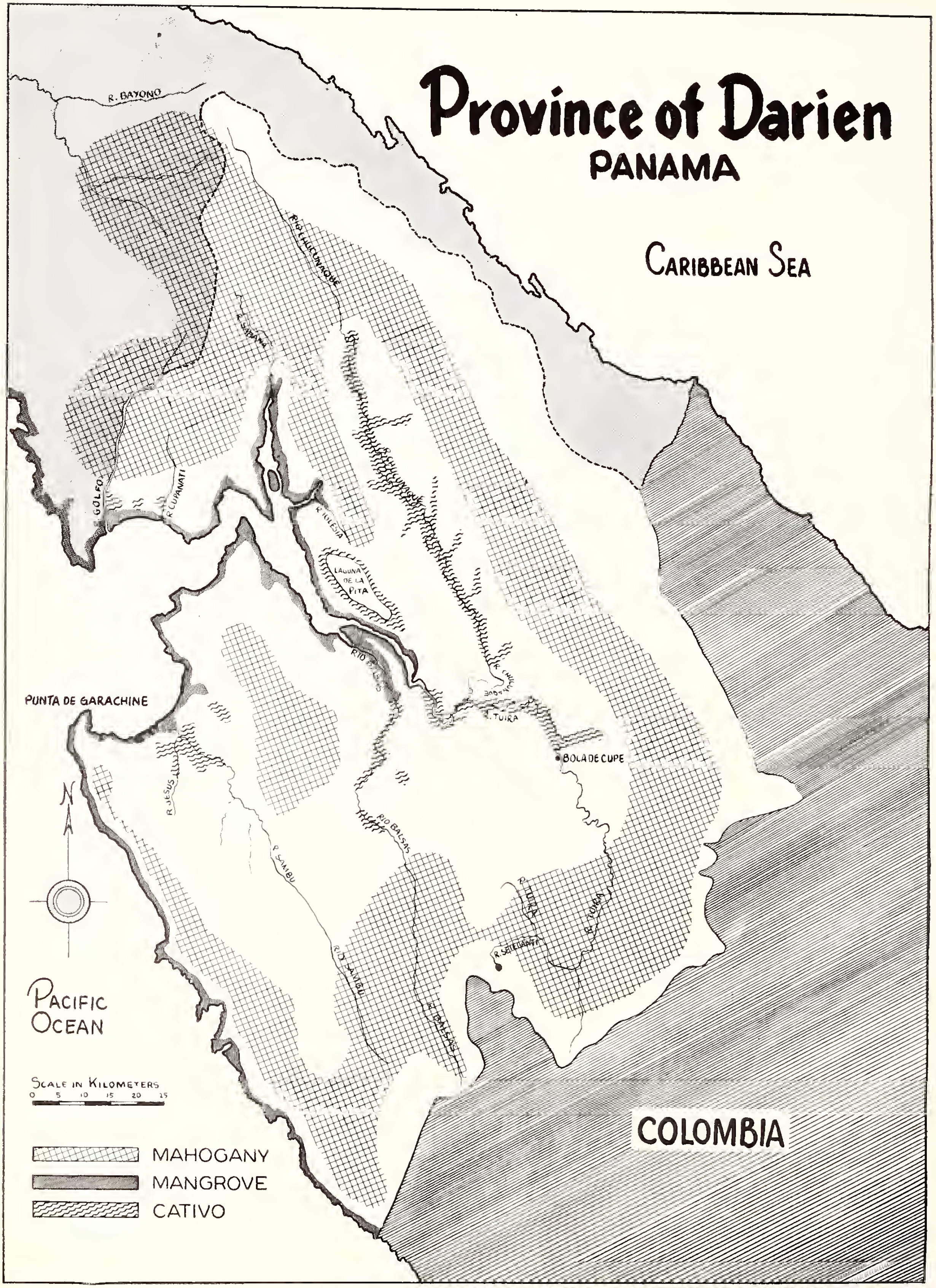
In areas affected by tidal overflow or subject to continuous flooding during the wet season from May until January specialized types of lowland forest have developed.

Cativo

Cativo is found in great abundance in Darien on low flooded areas along streams and around shallow lagoons. It occurs in almost pure stands in many areas. Associated species are tangare (*Carapa* sp.) and coco (*Lecythis* sp.) Cativo reaches its optimum development on the natural levees along meandering streams where there is always an abundance of water and frequent flooding takes place during the rainy season. The best stands of cativo occur above the influence of salt water.

A survey of the cativo stands on several of the rivers in Darien showed it to grow along the lower Rio Chucunaque, Rio Tuira, Río Balsas, Rio Sambú, Rio Congo, Rio Cupanati, and around the Laguna de la Pita. (See map)

The Río Balsas, flowing through its meander belt, has built up natural levees on both banks which are higher than the surrounding country. The best drained land is along the river, gradually sloping off to forested swamp 1 to 2 kilometers from the stream. Excellent nearly pure stands of cativo occur on both banks of Rio Balsas from



Province of Darien
PANAMA
Caribbean Sea
R. BAYONO
PUNTA DE GARACHINE
LAGUNA DE LA PITA
R. TUIRA
BOLA DE CUPE
RIO BALSAS
R. JESUS
R. SAMBU
N
Pacific Ocean
Scale in Kilometers
0 5 10 15 20 25
MAHOGANY
MANGROVE
CATIVO
COLOMBIA

Piriaqui up river approximately 20 kilometers. It was found that the greatest concentrations of this timber occur on the levee near the river, and that volume and timber size diminish as swampy ground is approached further inland. The belt of commercial cativo forest averages 1 kilometer in depth on each bank of the river, giving a total area of high quality cativo forest of 40,000 square kilometers. The stand varies from 35,000 board feet per hectare in the best areas near the river to 12,000 board feet per hectare further inland. The average stand for the area was estimated to be 30,000 board feet giving a total volume of 60,000,000 board feet for the valley.

Judging from an examination of felled trees in the area and the quality of logs received at the plywood plant, at least one-half of this volume, or 40,000,000 board feet, is face veneer quality material. Of the remainder approximately 30,000,000 board feet is suitable for core stock and 10,000,000 board feet for lumber.

On Río Tuira the first cativo is encountered approximately 25 kilometers up river from the mouth of the Rio Balsas at a location also called Piriaqui. From this point up river to the mouth of the Rio Chucunaque, a distance of 25 kilometers, the river bank forest is made up largely of cativo. However, a cruise of this forest shows that the volume of timber per hectare is considerably below that in the cativo forest on Rio Balsas. In many places the strip of forest is quite narrow, with the land sloping off into a shallow lagune. This timber volume of the strip along this river averages 10,000 board feet per hectare, and the highest volume per hectare found was 20,000 board feet. The 4,000 hectares of forest land between Piriaqui and the mouth of the Chucunaque extending 1 kilometer back from the river bank contain 40,000,000 board feet of cativo. Cativo forest is found on the Rio Tuira above the mouth of the Chucunaque as far South as Boca Cupe. These forests have not been examinated. However, the total stand of cativo on the Rio Tuira is probably in excess of 100,000,000 board feet.

On Rio Sambu the first cativo is encountered approximately 10 kilometers up from the river mouth at the confluence of Rio Jesus with the Sambu. A continuous stand of cativo occurs along the river from this point up river for a distance of 8 kilometers or to a point where the Quebrada Morobichi flows into the river. The timber in this area was examined and was found to extend at least 1,500 meters inland from the river bank on either side of the river. The timber volume varies from 5,000 to 30,000 board feet per hectare. In the 3,000 hectares cruised the average stand is 15,000 board feet per hectare giving a total volume of 42,000,000 board feet. From the mouth of the Morobichi upstream the former river bank stands of cativo have been cleared for agriculture. However, this clearing is only a narrow strip along the river, and cativo remains further inland. It is estimated from information obtained from local residents and cruise data that the total volume of cativo available from the Rio Sambu is approximately 100,000,000 board feet.

Rio Chucunaque, flowing into the Rio Tuira just below El Real, is reported to have extensive stands of cativo along its meandering course for a distance of 80 kilometers. Some of the best quality cativo logs received at the plant came from this river. No surveys have been made in this area. However, all available sources of information indicate a volume in excess of 200,000,000 board feet existing in this drainage.

There are several smaller areas of cativo in Darien that have not been surveyed (See map). From the information available it is estimated that the total volume of cativo in Darien is in excess of 500,000,000 board feet.

During recent years considerable interest has developed in the use of cativo for both face veneer and core stock in the fabrication of plywood. At the present time approximately 1,000,000 board feet per month are being shipped to the United States from Costa Rica and Colombia. At the plywood plant in Panama as much as 400,000 board feet of cativo a month has been used for both core stock and face veneer. Highly decorative face veneers have been made on both the rotary lathe and the slicer. Decorative cativo plywood is sold with the light colored woods and probably could be made competitive with birch. An interesting architectural application of cativo plywood can be seen in the Chase National Bank in Panama.

Cativo is also suitable for box boards, and an effort should be made in Panama to fabricate out of cativo the boxes used locally. All of the cases used for beer and carbonated drinks could be made out of cativo if local manufacturing facilities were established. The boards should be treated with pentachlorophenol and benzene hexachloride while green to make them more durable.

The nature of the cativo forest is such that selective cutting can take place without destroying the productive capacity of the forest. This tree is a prolific seed producer, and reproduction in all stages of development is abundant in the cativo forest. No detailed studies have been made to determine what proportion of the stand can be cut before a significant change in composition takes place. However, it has been observed that where up to 50 percent of the total volume was cut stands closed up and remained pure cativo. On the other hand, where the cativo forest is felled in order to plant rice, cativo does not inmediately reoccupy the land after cultivation ceases. A temporary association of short-lived species such as guarumo (*Cecropia* sp.) and balsa (*Ochroma* sp.) occupies the site first and is probably gradually replaced by cativo.

In the cativo forest where no cutting takes place growth balances the mortality, and the forest remains more or less stable. It is only through utilization of the mature trees that this type of forest can be made to contribute to the local economy. Cutting makes possible an increased rate of growth by providing more growing space for the young trees left behind. No studies have been made to determine what rate of cutting the cativo forest will support. However, in the best cativo stands where cutting removes the mature trees a growth rate of at least 1,000 board feet per hectare per year should be achieved.

The cativo forests of Darien represent a tremendous source of industrial raw material, and general observations indicate that with a minimum of control over cutting operations the forest can be maintained in a continuously productive state. It should be the policy of the government to do everything possible to encourage the utilization of cativo.

Mangrove

Since a use has been found for ground mangrove bark in the mud conditioning chemicals used in drilling oil wells this tree provides an important source of income for Panama. Extensive pure stands of mangrove (*Rhizophora mangle* L.) extend all along the Pacific Coast of Panama. No surveys of this type of forest have been made. However, because of its potential importance estimates should be made of the volume of bark available. Harvesting of the bark results in the death of the tree. However, natural reproduction will replace the trees cut and provide a continuous source of raw material so long as the rate of harvest does not exceed the growth of new trees.

THE PRODUCTION OF MAHOGANY

Logging

Except for a few locations on Rio Chucunaque all the mahogany that can be cut and rolled into the rivers by hand methods has already been logged. Logging operations now and in the future will depend on mechanical equipment such as tractors and trucks

to bring the logs out to streams where they can be rafted for towing to sawmills or log boats.

Present day logging operations on Rio Sabana and elsewhere are organized on the basis of skidding the mahogany logs as far as 2 kilometers to truck loading points and hauling by truck from 8 to 25 kilometers to the log dump on a stream bank. In other mahogany producing countries in Central América logs are being transported by truck as far as 100 kilometers to stream banks.

A large proportion of the mahogany timber in Darien is over-mature and defective. The most common defects encountered are termite damage and heart rot, which are most often found in over-mature trees. On the logging operations organized by the Panama Forest Products Company through local contractors on Rio Sabana as many as one-half of the trees were found defective. This greatly increased the cost of logging since more trees had to be felled than was planned and logging operations had to be spread over a greater area than expected.

Because of the high cost of transportation it does not pay to bring defective logs out of the forest. Some contractors save a part of the defective logs by putting crews to whipsaw heavy planks out of the good portion of defective logs. Whether or not this operation pays depends on the local market for whipsawn planks. Everything possible should be done to promote the sale of this type of material to provide for more complete utilization of defective logs.

Future Supplies of Mahogany

Production of mahogany in Panama during the last 10 years averages approximately 3,000,000 board feet of which one-third is used locally and two-thirds is exported. Based on this rate of cutting the remaining stands of mahogany in Panama can be expected to last approximately 25 years.

The possibility of providing a continuous supply of mahogany lumber at this level of production on the basis of the mahogany growing stock left in Panama does not appear to be feasible since it will require at least 40 years and probably 50 years for planted mahogany to reach commercial size. The mahogany timber now being cut is an acumulation of mature and over-mature trees that has been developing over a period of several hundred years. On the other hand, it does not seem advisable to restrict the cutting of this timber in order to balance cutting against growth because much a high percentage is overmature and defective. If this timber is not cut promptly it will completely deteriorate.

Plantation Costs

Based on observations of planted mahogany in various countries in Central America the results to be expected from mahogany plantations are shown in the following calculations.

Operation	Cost per hectare Dollars
Preparing planting lines	$ 12.50
Planting including seed	12.50
Care 1st. year - 3 cleanings	12.50
Care 2nd. year - 2 cleanings	7.40
Care 3rd. year - 1 cleaning	5.00
Care 4th. year - 1 cleaning	5.00
Care 5th. year - cleaning and pruning	5.00
Care each year thereafter	2.50
Care, average for 50 years including $1.20 for administration and protection	3.97

Since mahogany is a light-demanding species, the most successful plantations have been established in second growth that springs up in abandoned agricultural clearings. This type of vegetation provides some protection for the young plants but does not create deep shade. Work expended on care of plantations should aim to keep the mahogany tree crowns free from interference above. If nursery stocks is transplanted it should be approximately 1 meter tall and all the leaves should be removed transplanting.

Planting should take place during the early part of the rainy season. Some success has also resulted from sowing seed directly in the forest. Planting should be at the rate of 250 trees per hectare, with the expectation of 125 crop trees at the end of the rotation.

The average annual volume increment based on available data will be approximately 1,235 board feet per hectare per year, or 61,750 board feet per hectare at the end of 50 years. The value of this harvest, based on present log values of $125.00 per thousand board feet is $7,718.75. If plantations are established in accessible areas the logging cost should not be more than $50.00 per thousand board feet leaving a net yield of $75.00 per thousand board feet or $4,631.35 per hectare.

The expectation value of 1 hectare of forest land planted to mahogany with the costs and yield just presented and a compound interest rate of 3.5 percent may be found by the following formula:

$$Se = \frac{Yr. + ta\,(1 + p^{r-a}) - c\,(1 + p^{r}) - E}{(1 + p^{r} - 1)}$$

Yr.	Yield at rotation age		$ 4,631.35
r.	Rotation — 50 years		
ta.	Thinnings. At the age of 25 years thinnings should be removed producing small sawtimber worth $40.50 per hectare. This amount prolonged to the end of the rotation is 40 $(1.035^{25}$ = (2.363) =		94.52
	Total periodic yield		4,725.87
c.	Cost of planting		
	Clearing planting lines	$ 12.50	
	Planting	12.50	
	Planting cost prolonged to the end of rotation		25.00
	$25(1.035^{50})$ = 25 (5.585) =		139.62
	Periodic yield less planting cost		4,586.25
	Periodic yield discounted to the present:		
	$\frac{4586.25}{1035^{50} - 1} = \frac{4586.25}{4585} =$		1,000.21
E.	The capitalized value of the average annual expense. That is, e/p where "e" is the annual expense and "p" the rate of interest.		
	$\frac{e}{p} = \frac{3.97}{.035} =$		113.43
Se.	Soil expectation value		$ 886.78

This calculation is for 1 hectare only. Assuming that a regulated forest property has been established that is capable of continuous production of mahogany, then for comparative calculations a sample of 50 hectares can be chosen on which each year 1 hectare of mature mohogany timber will be cut and 1 hectare planted. The value of a 50-hectare sample of such a regulated forest property would be as follows:

Income:		
Timber value from 1 hectare cut each year		$ 4,631.35
Thinnings from 1 hectare each year		40.00
Total annual income		$ 4,671.35
Costs:		
Planting 1 hectare each year	$ 25.00	
Annual expense on 50 hectares at $3.97	198.50	
Total cost		223.50
Net annual income		$ 4,447.85
Capital value of net annual income		
$\frac{4,447.85}{.035}$	$ 127,081.48	
Value per hectare		
$\frac{127,081.48}{50}$	$ 2,541.62	

The 3.5 percent rate of interest used in these calculations represents a reasonable rate of return in a relatively risk free market. When the values developed here are adjusted to compensate for special risks such as fire, wind damage and unstable land policies comparisons can be made with values calculated for other tropical crops or plans for land use. The values shown for mahogany should be of interest to both public and private investors .

RECOMENDATIONS

A complete inventory of the forests of Panama should be made in order to gather the information to provide an adequate basis for long range economic planning and for framing and adequate legislative program for the control of the exploitation of the forest resources. The forest laws should be so designed that they will encourage the utilization of the forest resources. Steps should be taken to study the administrative needs in controlling the use of the forest resources, and plans made for the establishment of an administrative organization.

The Inhibitory Action of Organic Chemicals on a Blue Stain Fungus

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As a result of the work of Wolcott[1/] with different organic chemicals in search of suitable repellents for the West Indian dry-wood termite, (*Cryptotermes brevis* Walker) the possibility that some of the termite-repellent organic chemicals might have inhibitory action on wood staining fungi was investigated. Obviously such a substance would be the ideal wood preservative.

Most of the substances tested are synthetic organic chemicals. Pinosylvin (3, 5-dihydroxy stilbene) was extracted from the heartwood of Scotch pine by Erdtman[2/]. Substituted derivatives of pinosylvin were made in the laboratory. Usnic, physodic, salazinic, and vulpinic acids are naturally occurring products of mold metabolism. 5, 7-dihydroxy flavone (chrysin) was obtained from buds of several varieties of poplar.

Methods

The indicator organism used in this study is a species of *Trichosporium*, obtained on primary isolation from stained (blue-green) commercially available wood. It was kept in stock cultures in Sabourad dextrose agar.

The basal medium to which the test substances were added has the following composition:

Substance	Percent
Dextrose	3.0
Ammonium nitrate	0.1
Potassium dihydrogen phosphate	0.1
Magnesium sulfate	0.005
Manganese sulfate	0.0002
Zinc sulfate	0.0002
Ferric chloride	0.001
Cobalt chloride	0.0002
Copper sulfate	0.0002

Most of the test substances were dissolved in acetone. Exceptions were: 5, 7-dihydroxy flavone, disolved in pyridine; 2,4-dichloro benzalaniline, 4-chlorobenzalaniline, and 2,4,-2,4-tetranitro stilbene which were dissolved in benzene. Anthragallol, anthracene, acenaphtene, copaivic acid, triphenyl stibine, phenanthrene quinhydrome, beta-chloro anthraquinone, 1-2-naphthoquinone, 2-methyl-1, 4-naphthoquinone, and 3-phenyl salycilic acid (cupric salt) were dissolved in ethyl alcohol due to their insolubility in acetone.

The controls consisted of basal medium with an equivalent amount of the solvent used in adding the test substance. During sterilization the solvents were completely evaporated. Addition of solutions of the test substance to the basal medium resulted in perfect solutions, but those dissolved in benzene and ethyl alcohol generally floculated, producing a suspension. The concentration of test substance used was 100 and 200 gammas per ml. They correspond to 0.01 and 0.02 percent, respectively.

After sterilization the pH of the basal medium was 4.5. It was assumed that the addition of the test substance did not change the pH of the medium, considering that it was well buffered, and that the concentration of the test substance was very low. Two procedures were used for inoculation and for growing. For Treatment No. 1 the following procedure was used: Pieces of mycelium grown in liquid basal medium were added to

1/ Walcatt, George N. 1950. The termite resistance of pinosylvin, stilbene and other new insecticides. P. R. Jaurn. Agr. Univ. P. R. 34(4):338-342.

2/ Erdtman, H. 1959. Heartwaad extractives af canifers: their fungicidal and insect-repellent properties and taxanamic interest. TAPPI 32(7):305-310.

the flask containing the test substance and the culture was allowed to grow for a period of 9 to 10 days with an occasional shaking. For Treatment No. 2 the inoculum consisted of 0.2 ml. of a spore suspension in 0.1 percent sodium lauryl sulfate. They were grown for 7 days in a rotary action flask shaker machine operating at 240 oscillations per minute. In both cases the temperature was 30°C (±) 2°. After the growth period the mycelium was filtered through a Buchner funnel and dried in the oven for 24 hours at 70°C. After drying the mycelium with the filter paper was weighed and by differences (from the weight of the filter paper before filtering) the weight of the mycelium was obtained.

Results and Discussion

Table 1 shows that pinosylvin and its derivatives are very good inhibitors of growth of *Trichosporium* sp. under the conditions of the test. It is of interest to note that when the hydrogen of the hydroxyl radicals is displaced by methyl groups (pinosylvin, dimethyl ether) the activity is reduced. It is apparent that some of the activity of pinosylvin resides in the presence of at least one free hydroxyl group. The substituted, 2,6-dibromo pinosylvin lacks inhibiting activity, which is possibly due to the fact that it is the dimethyl ether form.

Table 1. — Mycelium weights from Treatment No. 1

Test substance	Weight of mycelium	
	100 gammas per ml.	200 gammas per ml.
	Mg.	Mg.
1. Pinosylvin	1.1	1.6
2. Pinosylvin (monomethyl ether)	2.4	1.2
3. Pinosylvin (dimethyl ether)	37.4	36.2
4. Dihydro pinosylvin (monomethyl ether)	3.7	3.8
5. 3, 4, 6 — trinitro stilbene	20.0	10.5
6. Vulpinic acid	29.8	21.4
7. Salazinic acid	33.6	61.6
8. Usnic acid	41.7	8.1
9. Physodic acid	31.7	13.3
10. Phenanthraquinone	1.8	5.1
11. 1-1-di (2-hydroxy-3,5-dichloro phenyl 2, 2, 2-trichloroethane		5.4
Control for substances 1-11	87.4	93.1
12. 5, 7-dihydroxy flavone	8.2	11.4
Control for substance 12	5.8	3.0
13. 2, 4, 2,', 4' tetranitro stilbene	63.3	64.5
Control for substance 13	4.9	1.7
14. 2, 4-dichloro benzalaniline	55.7	61.7
15. 4-chloro benzalaniline	95.4	89.5
Control for substances 14 and 15	7.4	4.9
Complete medium alone	80.4	

Other substances tested as a part of the first group of eleven, but which showed little or no inhibitory action (40 + mg.) are as follows:

2,6-dibromo pinosylvin (dimethyl ether)
Benzalaniline

4-hydroxy benzaniline
4-methoxy benzalaniline
2-hydroxy benzalaniline
2,4-dihydroxy benzalaniline
3,4-dimethoxy benzalaniline
3,4-dehydroxy benzalaniline
2,4-dichloro stilbene
3,4-dimethoxy stilbene

3,4-methylene dioxy stilbene
2,4-dichloro-2', 4'-dinitro stilbene

Azobenzene
Dibenzyl
Diphenyl octatetraene
3,4,3'4'-tetramethoxy dibenzyl
2,3,6,7-tetramethoxy-9,10-dihydrophenanthrene
Dimethyl tetarachloro phthalate
P-cholorophenyl-p-chlorobenzene sulfonate

With the exception of 3-methoxy-4-hydroxy-5-chloro benzalaniline and 2,4,6,-trinitro stilbene, the substituted benzalanilines and stilbenes lack inhibitory action.

Usnic, physodic, salazinic and vulpinic acids are high molecular aromatic compounds with more than one ring and several side chains. As expected they proved to be inhibitory in varying degrees. The same is true for phenanthraquinone and for 1,1-di (2-hydroxy-3,-5-dichloro phenyl) 2,2,2-trichloro ethane, an analogue of D.D.T. Inhibitory action of chrysin is probably due to piridine, which in general is very toxic to molds. Benzene, as seen from the controls, is very toxic, in the presence of 2,4-dichloro and 4-chloro benzalaniline and 2,4,2',4'-tetranitro stilbene, which were dissolved in benzene, the organism was able to grow.

From Table 2 it can be seen that under the conditions of the experiment the following substances proved to be the best inhibitors for the species of *Trichosporium*: dinitro -O-cycloexyl phenol, dinitro-O-cresol, chloranil cyclopentadiene, para chloro-meta

Table 2. — **Mycelium weights from Treatment No. 2**

Test Substance	Weight of mycelium	
	100 gammas per ml.	200 gammas per ml.
	Mg.	Mg.
1. 3 - methoxy - 4 - hydroxy - 5 - chloro benzalaniline	140.9	1.9
Control for substance No. 1	230.3	235.7
2. Dinitro - O - phenyl phenol	85.5	86.1
3. Dinistro - O - cyclohexyl phenol	3.0	24.1
4. Dinitro O - cresol	4.2	3.7
5. Chloranil vyclopentadiene	40.0	1.6
6. Para chloro-meta xylenol	0.8	0.9
7. Quinone cyclooctatetraene	162.0	86.6
8. Dibenzoyl ethylene	1.1	1.0
Control for substances 2 to 8	218.6	212.9
9. Phenanthrene quinhydrome	2.5	4.2
10. 2 - methyl - 1, 4 - naphthoquinone	2.0	1.6
Control for substances 9 and 10	197.2	195.6
Complete medium alone	214.2	

xylenol, dibenzoyl ethylene, phenanthrene quinhydrome, and 2-methyl-1,4-naphthoquinone. Other substances tested in Treatment No. 2 showed little or no inhibitory action (80 + ml.) These are as follows:

3,4-methylene dioxy benzalaniline
2,3,4-trihydroxy benzalaniline
2-nitro benzalaniline
dihydroxy anthraquinone
Sodium tetrahydro naphthalene-beta-sulfonate
Resorcinol-acetone (Condensation product)
Alpha-penyl-4-hydroxycinnamic acid
Quinone cyclooctatetraene
Phenanthrene
Anthragallol
Anthracene
1,2-naphthoquinone
Beta-chloro anthraquinone
Triphenyl stibine
Acenaphtene
Copaivic acid

With these the inhibitory action is somewhat lower than for those of Treatment No. 1. Probably, an increase in concentration would result in an increase in inhibitory action.

In vitro inhibitory action of any of these substances may be due to several causes. Among those possible are the following:

1. Interference with a normal synthesizing enzyme system. A form of competitive inhibition in which the antagonist competes with a metabolite for the enzyme system.
2. Interference with membrane permeability, in which the antagonistic substances causes a change rendering the cell wall incapable of taking or disposing the necessary substance (one or series of them).
3. Interference with the reproductive mechanism of the organism resulting in cessation of reproduction and consequent death.
4. Radical changes in the physical environment of the cell brought about by the antagonistic substance outside or inside the cell which will finally result in no growth and death.
5. Possible conversion of the antagonist, by sterilization or other process, into the actual antagonistic substance.

Concerning the last possible cause it is of interest to note that Rennerfelt[3/] conducting a series of experiments with pinosylvin and different microorganisms, thought that these compounds might be converted into phenol (or derivatives) and benzoic acid, both being poisonous to fungi. He concluded that for certain organisms the concentration of phenol required to produce an equivalent inhibition to that of pinosylvin was considerably higher.

The stilbene derivatives are synthesized from stilbene which is the parent compound of stilbestrol and diethyl stilbestrol, two of the synthetic sex hormones used by humans. With respect to this, Brownlee et al[4/] synthesized a series of stilbene derivatives similar to sex hormones and they all had activity against staphylococci and streptococci. The best substance they found was 4-hydroxy diethyl stilbene.

The best in vitro inhibitors should be tried in field tests. Observations could be made on how they behave under actual working conditions. The possibility that higher concentrations of the non-inhibitory substances could inhibit is not excluded. They were not made mainly because the amounts were very small.

In a similar series of experiments made by the author[5/] with *Fusarium oxysporum* var. *cubense* and var. *vanillae*, the same general results were obtained. Field trials are now being conducted with some of these substances .

3/ Rennerfelt, E. 1945. The influence of the phenolic compounds in the heartwood of Scots pine (**Pinus silvestris L.**) on the growth of some decay fungi in nutrient solutions. Svensk Botanisk fids Krift Bd. 39, H 4.

4/ Brownlee, G., Copp., F. C. Duffin, W.M., and Tonkins, I. M. 1943. The antibacterial action of some stilbene derivatives. Biochem. J. 37,572-7.

5/ Ascorbe, F. J. 1952. Unpublished data.

OUR EFFORTS TO CONSERVE TREES [1]

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Río Piedras, Puerto Rico

Previous papers in this symposium have shown the importance of trees to Puerto Rico. They are of importance for much more than merely the wood they produce. They may yield fruits or fibers or may serve for beautification. Considered in the aggregate, forests of trees also are of value for the control of soil erosion and the runoff of water, as refuges for beneficial or attractive wildlife, or as peaceful environment for outdoor recreation.

In spite of all of these values nearly all of the island has been deforested, some areas several times. Generally this has been done to permit settlement, for the production of cultivated crops or forage, or to harvest the trees themselves. The necessity and importance of these activities on many areas is generally recognized, but what has been, is being, and should be done to perpetuate the benefits of trees where trees are needed?

Tree Conservation in the Past

The effort to conserve trees in Puerto Rico is not a new activity. A number of the early Spanish laws which applied to Puerto Rico reflected the scarcity of forest products in that country. Later, when Puerto Rico's forests retreated so far that building materials became locally scarce and some of the streams disappeared during dry weather a number of local laws were passed to conserve the trees.

In the "Ley Primera," in 1513, Ferdinand V offered the people land, a part of which was to be planted to trees (*3*). In 1536 Charles I ordered settlers to whom lands were distributed to plant trees along their boundaries, so that it would be possible to use the timber (*3*). The first indication of interest within Puerto Rico in forest conservation was government Circular No. 493 in 1824 presenting the recommendation of Miguel de la Torre that strips of trees be left along and at the source of the stream (*5*).

In 1839 Isabella II ordered the establishment of a board in Puerto Rico to protect forest, fish, and wildlife (*6*). In 1843 this board approved a number of resolutions, among which some were about as follows:

1. Timber cutting on lands best suited for forest should be only in the form of thinnings.
2. In the cutting of the Crown forests care must be taken to maintain conditions satisfactory for reproduction.
3. Where necessary the Crown forests should be reforested after cutting.
4. Palms should be planted near dwellings because of their proven effect in keeping lightning away.
5. No cutting is permitted on the margins or in the headwaters of rivers, on either Crown or private land.
6. Ucar, capá blanco, capá prieto, mangle botoncillo, mangle colorado, maría, ausubo, algarrobo, cóbana, roble, laurel, and cedro are to be reserved for naval use.

Circular No. 34 of the Puerto Rican government in 1844 required that each municipality plant trees on the boundaries of Crown lands and along roads. This may mark the beginning of our roadside trees. It also called for the establishment of a public forestry agency. The mayors were to locate and determine the area of public lands within their municipalities which should be kept forested by this agency. (*5*).

By royal order in 1850 those lands which reverted to the Crown because they had not

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been cultivated in accordance with the terms of the concession were, if best suited for forest, to be withheld from further sale and placed under the administration of a government forest engineer.

A royal order in 1853 ordered the preparation of a forest law, the location and marking of Crown lands, and the collection of data as to the amounts and methods of cutting. Two foresters were sent from Spain on a 3-year mission to help set up the project (*6*). In 1859 a circular prohibited the cutting of the best trees for fuelwood, as they were to be dedicated to higher uses (*5*).

A budget for public forestry, 2,800 pesos, first appears in the record in 1860 (*5*), although reference is made in legislation 10 years earlier to the position of public forest engineer. Nevertheless, in 1870 the forestry appropriation was discontinued by the local government as an economy measure, since it was thought that forestry was not necessary in a country where forests were scarce. Almost immediately thereafter a large area of Crown lands passed into private ownership, including Guilarte Peak.

In 1875 the Governor General signed a decree prohibiting clearing and burning on all lands private as well as public, unless a permit was obtained from the mayor. The mayors were to follow the instructions of a government forest inspector. In 1876 a royal order put a stop to the free distribution of land and specified that before land sales were made the forest inspector should examine all Crown lands to prevent the alienation of those which should remain in forest. Ten percent of the receipts from the sales of the Crown lands and of forest products from them was to be used for reforestation and forest improvement.

A forest law was promulgated by Alfonso XII in 1876 establishing forest reserves and providing for their protection (*2*). Crown forest reserves were to be set aside where needed for erosion control, conservation of well levels, regulation of rivers, maintenance of rains, and protection against wind. Municipal forests were to be set aside from Crown lands for each village. These were to be administered locally by the mayors; all others by the Forest Inspector, who was in charge throughout the island. The Forest Inspector was to decide jointly with the local mayor, a year ahead, which trees should be cut from the municipal forests and was to make plans for forest improvement. The royal mark was to be placed on all trees to be cut.

To assist in the carrying out of this forest law an office of the Spanish "Cuerpo Nacional de Ingenieros de Montes" was maintained in Puerto Rico for at least the next nine years, and an apropriation for forestry was restored by the local government. A new Puerto Rican forestry organization was set up under the "Negociado de Obras Públicas, Construcciones Civiles, Montes y Minas" and was referred to as the "Inspección de Montes de Puerto Rico" or the "Servicio de Vigilancia de Montes". In 1877-78, 3,800 pesos were assigned for personnel, divided among an inspector, two asistants, a clerk, and an orderly. Sixteen-hundred pesos were provided for location of boundaries, office rent, books, and instruments. The following year the same personnel carried on, but the total appropriation was cut to 5,100 pesos. The mangroves, historically of value for naval construction, were transferred from the Navy to the "Inspección de Montes" in 1877 in spite of dissention by the Navy.

The first forest region, containing about 26,000 acres in the Luquillo Mountains and the eastern mangroves ,had been established by 1885 and was protected by one guard. A second region apparently centered at Utuado. About a dozen timber trespass cases were heard in 1885 before the mayor of Luquillo and several were won by the government. From 1877 to 1888 detailed plans were made for exploitation of public timber, based upon estimates of volume, age classes, and rotation. These plans contemplated cutting more than 17,000 acres of forest annually. However, few cutting records are to be found, and descriptions of the different Crown forest areas by the "Inspección" were so vague

as to indicate that the Forest Inspector was not well acquainted with conditions in the field and that plans were far ahead of progress. At least 20 auctions of standing timber were held in the first region from 1885 to 1888. Some of the timber sale contract clauses were essentially the same as those of today.

It is evident that Puerto Rico had progressive forestry legislation during the 19th century. Although the historical record is not all clear, the extent and condition of the island's forest resources as described at the end of that century testify to the fact that conservation efforts were not very effective.

Following the Spanish-American War the American government at first paid even less attention to forest conservation. On January 17, 1903 President Theodore Roosevelt set aside most of the former Spanish Crown lands within the Luquillo Mountains as the Luquillo Forest Reserve, to be administered by the Federal Bureau of Forestry. However, the area was not provided protection until 15 years later.

In 1909 the Puerto Rico Comissioner of Agriculture and Labor wrote the Forester in Washington, recommending that guards be hired. He stated that charcoal makers were deforesting to the tops of the mountains. The Forest Service, which had by then replaced the Bureau of Forestry, sent a representative to Puerto Rico in 1910 who reported, however, that the area was too small to administer efficiently as a National Forest and suggested that it be turned over to the local government. The Governor objected on the grounds that the help of the Forest Service was needed, and stated that its withdrawal would be "exceedingly regretted". He offered forested tracts east of the reserve area to the Federal government if the Forest Service would send a superintendent.

In 1911 the Insular government again petitioned the Forest Service to send experts to restudy the area. J. G. Peters and L. S. Murphy came and made a reconnaissance of the forests and forest problems of the entire island. They found records of land ownership chaotic in the Luquillo Mountains and again recommended that the Forest Service withdraw. The Insular government again objected, upon which Murphy recomended a boundary survey, using Insular engineers and Federal funds. The survey was completed in 1916 and showed the public forest to contain 12,443 acres. A Federal forest supervisor was put in charge in 1917, and two guards were hired in 1918.

Upon Murphy's recommendation an unsuccessful attempt was made to set up a local forest service in 1912. Finally, in 1917, a Porto Rico Forest Service was established in the Department of Agriculture and Labor. In 1918 this Service was assigned the administration of some 15,000 acres of unalienated mangrove forest. In 1919 blocks of public nonagricultural land at Guánica and Maricao, and on Mona Island were added.

Expansion of the original public forest areas has taken place in various ways. Since 1931 an additional 13,888 acres have been acquired in the Luquillo Mountains, partly by transfer from the local government but mostly by purchase, by the Federal government.

In 1935 the Federal Forest Service established a Purchase Unit in the Cordillera Central, the Toro Negro, containing a gross area of 120,000 acres. Since that time 6,688 acres have been acquired there.

In 1935, the Puerto Rico Reconstruction Administration of the U. S. Department of the Interior set up a third Forest Service. This Service established five forests —Carite, Río Abajo, Guajataca, Guilarte, and Susúa— containing a total area of about 21,750 acres. In 1943 the PRRA Forest Service was discontinued, and its lands were divided between the other two Services. In 1946 Mona Island was transferred from the Puerto Rico Forest Service to the Agricultural Development Company.

It has been the objective of the public forest agencies to develop and to use conservatively all of the resources of the forest reserves. Planting began in about 1922, and many exotic tree species were tested. A total of about 37,000,000 trees have been planted and there are now about 16,000 acres of satisfactory plantations. About 7,500 acres of forest have been improved by silvicultural cuttings. Approximately 3,700,000 cubic feet of timber have been cut in accordance with the principles of silviculture. One hundred and sixty miles of developmental roads and 250 miles of trails have been constructed. Recreation facilities and trails have been constructed at six different sites on the island. About 1,600 acres of land suitable for farming have been made available in small parcels to 270 families. To date, the total expenditure on the public forests (and their development) exceeds $15,000,000.

The government has also been interested in encouraging better practices on private forest lands. A law passed in 1925 provides for a fixed assessment of 1 dollar per cuerda annually for 5 years for deforested lands which are planted with at least 600 trees per cuerda. Another law, passed in 1930, exempts from taxation properties of not less than 50 cuerdas devoted to the production of trees for commercial purposes or the conservation of river sources and banks. Neither of these laws has been very effective, apparently because the saving in taxes is not sufficient to offset the "retirement" of the land from subsistence farming.

Since 1921 the local government has provided an apropriation for propagation of tree seedlings for distribution to farmers. This appropriation has been augmented by Federal funds under the Clarke-McNary Act since 1926, and the Norris-Doxey Act since 1937. The total expenditure to 1952, both State and Federal, is about $785,000. More than 50,000,000 trees have been propagated and distributed.

The position of Extension Forester has existed in the Agricultural Extension Service since 1928. The Extension Forester has been active in distributing trees to farmers and in dissemination of forestry information to rural people through the agents of that Service.

Forest research has been conducted on a small scale in Puerto Rico almost since the Forest Services were established. Planting studies began as early as 1920 (*1*) In 1939, the Southern Forest Experiment Station laid out a regeneration research program. At the end of that year the Tropical Forest Experiment Station was established at Río Piedras. Since that time this Station has had at least two professional foresters conducting research on the problems of both private and public forest lands. The present program includes chiefly studies of regeneration and silviculture, but through the cooperation of the Division of Forests of the Commonwealth wood utilization research is now being initiated.

Another recent step toward better management of Puerto Rico's forests is an island-wide forest survey conducted by the Division of Forests of the Commonwealth to determine the character and quantity of Puerto Rico's forest resources. This survey is nearly completed.

Quite apart from forest conservation considerable areas have been planted to tree crops and managed to our benefit. Coconuts, coffee, and citrus were introduced early and all are important crops today. The bay rum tree was also placed under cultivation at an early date. Systematic roadside tree planting was begun more than 100 years ago, in recognition of shade as an important tree product.

Some Elements of a Future Tree Conservation Program

The production of a maximum of tree products consistent with proper land use requires a continued effort on the part of the government and landowners.

Recognition of Tree Land

On paper, tree land might be defined as that on which the best suited crop is a closed

tree cover, or forest, without regard to its present cover or use: where trees produce a higher sustained yield, in terms of economic and/or social benefits, than other crops. On the ground, on the other hand, definition is not so simple. It is at present usually impossible to compare the returns from tree and nontree crops. We do not yet know from experience the costs of producing forests of any specified size or volume. Even were these known the future value of such yield, when it becomes available, is still an unknown.

One category of lands, however, should be recognized by all as tree land: those areas which because of excessive slope (nearly all lands of more than 50 percent slope, according to the Soil Conservation Service); heavy rainfall; or shallow, infertile, or poorly-drained soil cannot be cultivated or pastured continuously without soil deterioration and/or very low yields, yet which can produce trees as a permanent crop. The area of such tree land, estimated from studies of topographic and soil maps, is not less than 600,000 acres, or about one quarter of the land surface of the island. For the present we might well limit our efforts largely to this area.

Sharing the Responsibility

In the past the greatest effort to conserve trees has been that of the government. It is necessary that the government assume this leadership because of the social values involved in forestry, the uncertainty and long time character of tree production, and the degraded condition of large areas of tree lands, the betterment of which involves an investment which does not interest private capital.

Nevertheless, it should be recognized that the government cannot do the whole job or even any large part of it. Nearly 90 percent of the tree lands are in private ownership, many of them in small scattered tracts. The government cannot afford to purchase and manage all of these tree lands. Wherever returns from tree crops (such as coffee) are adequate to interest private production this should be encouraged.

The program should be a joint one, with the landowner fully aware of the need for trees and willing to plant and manage them wherever there is a reasonable opportunity for returns. The government, on the other hand, should do everything reasonable to make tree culture an enterprise which is attractive to landowners.

The Task of the Government

The future of tree conservation, although it requires the cooperation of landowners, is at present largely in the hands of the government. It is the government, which through education, research, demonstration, and legislation, must induce the farmer to produce tree crops.

The first step is undoubtedly and acceleration of the educational program. Although two or three million forest trees are planted annually by farmers, the species selected and planting methods often are based upon inadequate knowledge and result either in complete failure or something less than could have been expected. It may be true that the best tree crops we know, including coffee, are not attractive to many farmers, but still more regrettable is the fact that the farmers, are often not fully aware of even those possibilities which do exist. It seems safe to say that a large proportion of the 50,000,000 timber trees planted by farmers in past years were planted because the farmer had an innate love for trees from the aesthetic standpoint, not because he was counting on a profitable harvest. We must show the economic side much more effectively.

If the farmer is eventually to carry the chief responsibility for tree culture we must make it much more attractive to him than present knowledge permits. This calls for an accelerated public forest research program. New, and more profitable tree crops must be introduced or developed. This may include fruits, nuts, fibers, and other nontimber products as well as timber. Better production methods with existing crops must be developed to permit earlier harvesting, greater yields, and cheaper management. Better

include processing of fruits and coffee, new uses for timber, and wood preservation.

The government must asure protection of soil and water resources and the productivity of critical tree lands where private tree culture is non-existent and unlikely before social values are lost. This calls for an accelerated public land acquisition program. Of the 600,000 acres of tree lands steeper than 50 percent slope, some 427,000 acres are in blocks of 10,000 acres or more, where population tends to be sparse and roads, schools, and other comunity services are expensive. This area, which includes poor soils and critical watershed lands, lends itself to efficient large scale tree or forest management. Part of the area is today producing coffee under tree shade. Nevertheless, more than half of the area is deforested and subject to shifting cultivation. Where tree crops can be made attractive to private owners on these lands, they should be induced to produce them. Elsewhere the only recourse appears to be the acquisition and conservation of these areas by the public. In this category are more than 100,000 acres in the Sierra de Cayey, on the south slope of the Cordillera, in the Atalaya Mountains near Añasco, in the northern limestone region, and in the watersheds of the Arecibo, Manatí, and La Plata rivers. The eventual total which must be acquired depends largely on the progress which can be made through research, extension, and incentives to obtain satisfactory tree culture on the private lands in these areas.

On public forest lands the government must do more than to merely protect the soil, water, and tree resources. These lands should serve as demonstrations of good timber management. They should serve as refuges for beneficial wildlife and their natural beauty should be made available to all in well planned public recreation areas.

Another aspect of public responsibility for tree culture is roadside beautification. As a result of the appreciation of trees by our techniques for processing and utilizing tree products must be worked out to make the most of what is produced. This should forefathers we have received a precious heritage in our roadside trees, estimated to cover at least 15,000 acres. We are in an environment much more favorable to roadside tree planting than that when they began this work. There are now more roads, more road planning is being done, more money is available for road maintenance, more people use and see the roads, and many new ornamental trees have been introduced into the island. Under these conditions we should be able to maintain our better roadside trees and to gradually replace some of them with more attractive species.

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ARBOLES EN LA FINCA [1]

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Hoy se ha tratado y se seguirá tratando de la importancia y el papel que juega el árbol como conjunto y como individuo en diferentes aspectos de la economía y vida agrícola y social de la isla. Entre estos aspectos hay uno que está, podríamos decir, más atado directamente al agricultor y a su finca. Que por ser más palpable y por resaltar más a la vista de todos, quizás puede despertar más interés en nuestro agricultor y más empeño en ser mejorado por éste. Nos referimos al papel que juegan los árboles en la finca. A la silvicultura aplicada a la finca. Al pequeño predio dedicado a bosque de subsistencia que debe existir en todo negocio agrícola, no importa su tamaño o la cosecha a que se dedique.

El manejo adecuado de una arboleda de subsistencia en la finca puede hacer al agricultor autosuficiente en sus necesidades ordinarias y corrientes por productos forestales. Puede suplir sus necesidades en madera de construcción, espeques para las cercas, leña para quemar, carbón, frutas, etc., y hasta puede haber un sobrante que muy bien puede venderse en los alrededores. No solamente producirían un bosque de subsistencia, estos productos forestales palpables, sino que daría al agricultor un sinnúmero de beneficios intangibles pero no menos valiosos como la protección de sus cosechas agrícolas, sirviéndole como rompevientos, y como una barrera positiva y permanente contra los arrastres; mejorando y rehaciendo suelo; conservando la humedad; y embelleciendo la finca para suplir un sitio apropiado para recreo y esparcimiento del espíritu.

Las arboledas no necesitan ocupar terrenos valiosos, terrenos agrícolas, donde crecerían bien y producirían rendimiento económico otras cosechas agrícolas. Los árboles, por regla general se siembran en los pedazos menos fértiles, más abruptos, más erodados y menos productivos de la finca. Predios que no rinden provecho alguno por ser improductivos, agrícolamente hablando. En fincas pequeñas, que estén enteramente bajo cultivo agrícola, podría muy bien usarse las colindancias, mediante la siembra de cercas vivas de especies apropiadas para la producción por el agricultor de muchos de los productos forestales que necesita.

En las fincas de Puerto Rico son muchos los predios que caen de lleno en la clase de suelos no agrícolas, severamente erodados, incapaces de producir alguna cosecha económicamente. Cerca de un 15 por ciento de toda la tierra en fincas es tierra de bosque, y en algunas fincas la proporción de terrenos de bosque llega hasta un 60 por ciento. Esto representa un área total de alrededor de 85,000 cuerdas. Un cuerdaje similar al que actualmente poseen y manejan los Servicios Estatal y Federal de Bosques. Esto naturalmente no incluye un número positivamente mayor de terrenos forestales que por estar en bloques extensos no los consideramos como terrenos en fincas. Toda esta tierra es potencialmente valiosa y esta potencialidad podría realizarse si se sometieran a un manejo adecuado. Sería bueno que antes de seguir adelante definieramos lo que nosotros entendemos por tierra de bosques o terreno forestal. Por tierra de bosque queremos significar toda aquella tierra donde la cosecha óptima sería una cubierta forestal completa sin importarnos para nada el uso actual que se le esté dando al terreno. Tierra donde el bosque sería la cosecha permanente más productiva en términos tanto económicos, de pesos y centavos, como en términos de beneficios sociales. Si una gran parte de esta tierra se dedicase a su uso lógico, nuestro agricultor

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podría tener una gran parte de la madera necesaria para las construcciones de su finca sin tener que obtenerlas de afuera. El agricultor podría tener estos productos forestales a la mano y al tiempo en que los necesita. Podría tener estos productos del bosque y además estaría conservando y mejorando esos suelos y aprovechando los distintos beneficios en el orden estético y biológico que una arboleda proporciona.

Ejemplo palpable de esta situación de mal uso del terreno podemos verlo claramente en los terrenos Tanamá y Aguilita del centro y noroeste de la isla. No solamente en esta zona la situación es alarmante, sino que en toda la isla es en general desalentadora. Con excepción hecha de algunas áreas aisladas en diferentes puntos de la isla como Cidra, Barranquitas, Cayey, Maricao y otros pocos, las fincas de café son prácticamente las únicas arboledas que existen en terrenos privados en la isla. Los terrenos forestales están abandonados y cuando más produciendo una fracción muy pequeña de su capacidad, y naturalmente, tienen un valor real actual muy por debajo de su valor potencial, siendo su aportación al ingreso de la finca completamente insignificante.

Esta situación ha traído naturalmente una escasez aguda de productos forestales. Esta escasez ha hecho que el consumidor haya tenido que mirar hacia productos substitutos para llenar sus necesidades aunque estos sean más costosos. Así vemos el aumento progresivo del gas Kerosina como combustible. Así vemos el uso de especies muy inferiores como espeques y postes. Así vemos que cada día se hace menor uso de la madera. Así vemos también que día a día y a pesar de los esfuerzos del Servicio de Conservación de Suelos se va agravando el problema de los arrastres y de la pérdida rápida del agua en los suelos.

Aunque nos place grandemente, por justicia, hacer reconocimiento del trabajo hecho por los Agentes Agrícolas, Agentes de Campo del Servicio de Conservación de Suelos y del Servicio de Bosques Insular y Federal, en el mejoramiento y multiplicación de los predios de bosque en las fincas, no podemos, sin embargo, dejar de traer a vuestra atención el hecho de que por desgracia, nuestro agricultor no parece darse verdadera cuenta de la importancia de dedicar parte de su finca a la producción de productos forestales que él mismo necesita y consume en su negocio agrícola y en su hogar. No parece nuestro agricultor darse cuenta de la magnitud de los problemas relacionados con la escasez de estos productos forestales. Con excepción de la arboleda necesaria para proteger las plantaciones de café y otras situaciones aisladas mencionadas antes, hasta la fecha no parece haber sido posible vender la idea de que la siembra de árboles puede llegar a ser una empresa económicamente atractiva al agricultor privado.

Creemos lógico enumerar para ustedes algunos de los problemas más importantes con que nos hemos encontrado en el desarrollo de nuestro trabajo por tratar de mejorar los bosques privados de la isla.

En primer término la escasez de tierra cultivable en Puerto Rico unida a la densidad enorme de nuestra población hace que la presión por el cultivo de la tierra sea demasiado fuerte. Hace que el agricultor trate de poner bajo cultivo agrícola, tierras que sabemos deberían estar dedicadas a pasto o a bosques. Esta situación hace que el agricultor, muchas veces, aunque comprenda la bondad del consejo de que dedique parte de estas tierras a bosque se vea en la necesidad de tratar de hacerlas producir alguna cosecha por la cual pueda conseguir crédito o alguna entrada inmediata. Así vemos como una cantidad crecida de cuerdas de tierra están sembradas de caña y frutos menores sin que podamos nosotros comprender como pueden rendir beneficio económico alguno a quien las cultiva. Tierras que lógicamente deberían estar dedicadas a arboledas para producir parte de los productos forestales y frutales necesarios y que tanto escasean en muchas zonas de la isla.

En segundo término se nos viene a la mente la mala selección de especies. Cuando

el agricultor se decide a dedicar parte de su finca a bosque, en lo primero que piensa es en talar la maleza que crece en la parte más inservible, desgastada y probablemente más erodada de su finca y sembrarla de árboles. Pero, y aquí está quizás una de las fallas más importantes del trabajo hecho hasta la fecha, solo piensa en especies valiosas, generalmente exóticas que de crecer bien podrían producirle maderas valiosas. Especies climax. Pero, ¿son esos terrenos apropiados para estas especies? ¿Está el medioambiente preparado para que estas especies climax puedan sobrevivir y desarrollarse? Generalmente no. Estas tierras degradadas, desnudas y erodadas han perdido todas las características comunes al bosque y para tener éxito en su repoblación hay que empezar mucho más abajo en la ecología. Hay que empezar con especies agresivas, peleadoras, fuertes, que puedan soportar y vencer esas condiciones adversas. Estas son las especies que pueden preparar el camino para el establecimiento y desarrollo de las especies valiosas que son más exigentes tanto en nutrientes como en condiciones ambientales. Es necesario pues convencer al agricultor de que por el momento, cuando éste sea su caso tiene que olvidarse de esas especies valiosas y conformarse con otras que aunque no de tanto valor, van siempre a producirle lo que él necesita: leña, espeques, postes y lo que es más importante aún, van a protegerle su suelo y van a preparar el terreno para que luego pueda venir la invasión por aquellas otras especies que el prefería. Las especiess climax.

Otro problema que frecuentemente confrontamos en el campo es el mal uso de las pocas arboledas que nos quedan. En este aspecto tenemos los dos extremos. Aquellos que creen que su bosque es un santuario donde no puede hacerse corta alguna y aquellos que cortan sin consideración alguna hasta que solo dejan una maleza inservible que apenas si les produce algún espeque regular y generalmente de especie inferior. Ambas prácticas son pobres e indeseables. En el primer caso además de ser una pérdida innecesaria de madera en los árboles que van muriendo y desapareciendo sin que nadie haga uso de ellos, las condiciones ambientales que obligatoriamente se desarrollan son tales que inhiben el crecimiento de los árboles jóvenes que puedan estar medrando bajo la sombra de los árboles más viejos. Este medioambiente característico de un predio de bosque bajo estas condiciones no solamente inhiben el crecimiento de los árboles jóvenes, sino que hacen que las condiciones sean muy poco apropiadas para la reproducción. En otras palabras, anulan dos de las características básicas de cualquier buen manejo forestal: conseguir el mayor crecimiento por unidad de terreno y conseguir una reproducción natural adecuada.

En el segundo caso, cuando se corta sin seguir normas aceptables de manejo, caso muy común y corriente, los resultados serán un bosque futuro de especies inferiores, calidad y forma indeseable y una población defectuosa.

No cabe duda que cuando se cuenta ya con un predio de bosque natural para empezar, no debiera nunca pensarse como se ha hecho tantas veces en suplantar este bosque por uno artificial. Debe sí pensarse en mejorarlo poniéndolo bajo un buen manejo. Para esto, naturalmente tiene que existir un liderato adiestrado que pueda guiar al agricultor en estas situaciones. Un liderato que por un medio u otro pueda convencer al agricultor de la necesidad para él y para su comunidad de que su pequeño bosque subsista. Que subsista y se mejore para que pueda llenar las necesidades del buen manejo y utilización de sus tierras. Para que produzca para él muchos de los productos forestales que él necesita en su hogar y en su finca.

La situación que hemos descrito en la isla, en cuanto al uso de los terrenos forestales o de bosque en las fincas privadas, necesita urgentemente de un liderato adicional inteligente y consciente del problema y que pueda interesar a nuestro agricultor en el restablecimiento de estos predios forestales. La motivación tiene que ser más amplia y mejor coordinada que hasta el presente. El

esfuerzo mayor tiene que ser hacia un mejor uso y ampliación de los recursos de que disponemos. Este esfuerzo puede traducirse en educación y ayuda técnica a los agricultores.

La educación, que la consideramos el punto clave, la piedra angular del éxito de cualquier campaña o programa que se implantase debe extenderse hasta incluir y dar énfasis al reconocimiento de los terrenos forestales dentro de la finca, las diferentes potencialidades de la cubierta forestal como productora de madera, frutas, fibras y otros productos del bosque. La protección de las cuencas; la conservación del suelo y la humedad; la estabilización del caudal de los cuerpos de agua para que podamos disponer de ellos, tanto en tiempos de sequía como en tiempo de lluvias y la provisión de un medioambiente propicio para un desarrollo más vasto de recreación al aire libre y un mejor establecimiento de nuestra fauna silvestre.

La ayuda técnica deberá, a su vez, incluir un programa amplio de investigación que llene las lagunas que existen actualmente en la información que podemos dar a nuestros agricultores. Deberá extenderse además hasta poder aconsejar al agricultor en la solución de sus problemas individuales, incluyendo ante todo demostraciones donde podamos demostrarle lo que le aconsejamos. Si es que vamos a continuar suministrando como hasta la fecha el material de propagación a usarse en la repoblación forestal en nuestras fincas, debemos investigar detalladamente las fallas enumeradas y hacer todo lo humanamente posible porque este material llegue á manos del agricultor en las mejores condiciones y en la época más apropiada. Unica manera de que la reforestación tenga una base sólida. Un principio adecuado.

Nos consta, por haber estado en relación directa con estos programas por muchos años, que nuestro gobierno se ha dado cuenta cabal y exacta del problema que nos ocupa. No nos cabe duda alguna de que hay cierta inquietud en todas las agencias al mirar y enfocar este problema. Podemos darnos cuenta de este creciente interés, por las solicitudes que nos llegan a diario recabando nuestra cooperación y ayuda en la formulación de planes para la siembra de pequeños predios en proyectos de las diferentes agencias gubernamentales como la Autoridad de Tierras, Autoridad de Hogares, Secretarías de Instrucción y Educación, etc. Esto sin lugar a dudas, sirve como medio de propaganda y divulgación. Pero es el estímulo en el agricultor, en el campesino lo que más nos debe de interesar. Es al agricultor, al campesino, al que vive en el campo y está diariamente viendo esa parte de su finca improductiva y desnuda a quien debemos interesar y estimular para que se convenza de que a él, a su finca, a su comunidad, a nuestro país todo, le conviene que él ponga a producir esa tierra que él cree inservible. Que la ponga a producir lo que, según la más básica reglamentación de la utilización racional de la tierra, debiera estar produciendo; árboles.

Esto sólo puede conseguirse de manera permanente mediante una campaña amplia, bien organizada y coordinada de educación. Una campaña que enfatize y realce la importancia del desarollo de un liderato adiestrado y consciente de la importancia de aumentar los recursos forestales de la isla, a través de la selección, adiestramiento y reconocimiento del mayor número de líderes voluntarios posible. Una campaña educativa que despierte la conciencia de nuestra juventud rural y jóvenes agricultores hacia una mejor comprensión de la importancia de los bosques.

Hemos dejado para discutirlo separadamente, por considerarlo de suma importancia, el problema de la sombra del café. Decidimos incluirlo porque como hemos dicho antes, las fincas de café son prácticamente las únicas arboledas que quedan en las fincas de nuestra isla y por considerar que los problemas de manejo de la sombra de una plantación de café, son básicamente problemas silviculturales. La sombra en los cafetales, tiene por objeto principal mantener las condiciones climatológicas más o menos invariables, principalmente en humedad. Esto equivale a hacer menos sensibles y bruscos los cambios del clima, asegurando los requisitos ideales para

el mejor mantenimiento de las plantas. Para que el agricultor pueda graduar su sombra de manera racional, es necesario que conozca las condiciones climatológicas del sitio, y las condiciones atmosféricas que reinan en la mayor parte del año, de la altura de su finca, condiciones actuales de sus árboles de sombra y las diferencias individuales de cada una de sus piezas de café. Es necesario que conozca las especies que tiene y las características de cada una de ellas. En fin, tiene que tener un conocimiento amplio de un buen número de árboles y de las condiciones y factores que afectan su desarrollo, manejo y reproducción.

Durante los últimos años se ha notado un resurgimiento del caficultor. Se ha notado una mejoría halagadora en la industria del café en nuestra isla. Y naturalmente, el caficultor ha fijado sus ojos en el silvicultor para que le resuelva sus problemas de la sombra Generalmente el cultivo del café se ha mirado solamente desde el punto de vista típicamente agrícola. Prácticamente todos los trabajos de experimentación llevados a cabo, han sido trabajos sobre el crecimiento, conducta y requerimientos del arbusto de café en sí. Es muy poco el trabajo que se ha hecho con la sombra que protege esas plantaciones de café. Es muy poca la importancia que se le ha dado a los problemas que existen con esta fase tan importante de ese cultivo.

Verdad es que podemos aconsejar al agricultor dándoles reglas generales que pueden servirle de guía para el manejo de su sombra. Verdad es que podemos decirle que para tierras bajas, de temperaturas altas y suelos resecos la sombra debe de ser muy tupida y de árboles de ramaje extenso; que para las tierras de temperatura fresca y húmeda la sombra debe ser menos espesa; y que para los sitios muy fríos y húmedos la sombra debe ser muy rala. También es verdad que podemos aconsejarlos en otros aspectos generales casi siempre en relación con la densidad de la sombra. Pero, ¿podemos acaso aconsejarlos sin duda ni titubeos sobre el combate de los males que afectan sus árboles de sombra? ¿Podemos ofrecerle algo nuevo, de lo cual estemos seguros, en especies y su adaptación? ¿En utilización de los tantos miles de pies cúbicos de madera que se pierden anualmente en las fincas de café? No nos cabe la menor duda de que hay mucho que hacer en la solución de los problemas silviculturales en la zona cafetalera de la isla. Tampoco nos cabe duda alguna de que es al silvicultor a quien toca resolver estos problemas y ofrecer una solución al agricultor de café.

Quizás la contribución más importante hecha al cafetal en los últimos años haya sido la introducción del guamá venezolano y su distribución entre los agricultores. No creemos, como ha llegado a creerse por algunos agricultores y hasta por algunos técnicos, que el guamá venezolano sea una panacea que nos venga a resolver todos los problemas de sombra, pero sí creemos que en ciertos y determinados casos y para determinadas zonas, si ha resuelto un problema de importancia. Durante los últimos años se han distribuído 3½ millones de arbolitos de guamá venezolano entre los agricultores de la región cafetalera y actualmente a la propagación de esta especie se le está dando gran importancia y auge en los viveros forestales.

Quizás también la solución de muchos de los problemas que afectan las fincas de café podría lograrse por los mismos medios usados en el manejo de los bosques. Deben investigarse las posibilidades del control biológico en la lucha contra enfermedades e insectos. Si la proporción de luz y agua y las condiciones del suelo mejoran estimulando el crecimiento rápido de todos los árboles del cafetal, los riesgos de enfermedades se reducen. Así mismo si se eliminan los árboles que han pasado su madurez biológica, se reducen grandemente las enfermedades.

Solo nos queda recordar que las generalizaciones en la preservación de maderas, en la importancia e influencia de los bosques y en la necesidad de conservar los recursos forestales ya se han vulgarizado lo suficiente en nuestro pueblo. Que si seguimos trayendo ante nuestra clase agrícola este tema sin una información estadística más convincente,

podemos caer en el error de matar su interés y hasta crear en ellos la sospecha de que no podemos probar lo que les decimos. Necesitamos presentarles datos, datos locales convincentes y de fácil comprobación. Necesitamos mostrarles ejemplos confiables de demostraciones donde se hayan resuelto sus problemas de una manera práctica. Nuestro agricultor cree cuando ve. La cosa más natural del mundo. Ejemplo palpable de esto es el caso de los agricultores de tabaco de la zona este de Puerto Rico. Estos agricultores han reconocido, viendo el ejemplo, la utilidad de la siembra de pino australiano en sus fincas. Han llegado a darse cuenta en tal forma que el pino podía resolverle uno de sus grandes problemas que ya la inmensa mayoría de los agricultores de Yabucoa, San Lorenzo, Juncos, Gurabo, etc. consideran la siembra de pinos, una siembra complementaria a la de tabaco. Han echado por el suelo el dicho de que cuando uno siembra árboles los siembra para sus hijos o nietos. Ellos han aprendido a hacer uso del pino desde que apenas el arbolito tiene una pulgada de diámetro. No queremos entrar en detalles sobre el uso verdaderamente intensivo que estos agricultores han aprendido a hacer de esta especie porque entendemos que el Agente Agrícola de uno de estos pueblos, les explicará en detalles el éxito obtenido por él en la siembra de árboles en su distrito. El Sr. Leguillou, Agente Agrícola de Yabucoa es un ejemplo típico de ese liderato inteligente, consciente del problema de nuestra isla, de cuya necesidad hice mención con anterioridad. El éxito alcanzado por el Sr. Leguillou nos demuestra lo que puede hacerse y nos alienta en nuestro trabajo al demostrarnos que nuestro agricultor responde cuando puede palpar las ventajas de lo que se le demuestra y aconseja.

No queremos terminar sin hacer un merecido reconocimiento del trabajo que está llevando a cabo el Servicio de Bosques Federal en el Bosque Experimental de Cambalache. Tenemos la bien fundada esperanza de que como resultado de estos trabajos en adaptabilidad de especies, costos, producción, rendimiento y usos, se puedan contestar con aceptable exactitud muchas de las preguntas que hace nuestro agricultor. Preguntas que tendremos que aprender a contestar si no queremos perder su confianza y hacer que ellos pierdan el interés que puedan desarrollar en el establecimiento y mantenimiento de predios forestales en sus fincas.

¿QUE ARBOL SEMBRARE [1]

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¿Qué especie de árbol sembraré frente a mi casa? ¿Que especies de árboles sembraré en mi finca? Estas, y otras preguntas parecidas, las hacen a diario muchas personas en la Isla. Desconocen los árboles a sembrar que embellezcan sus hogares, den sombra a la finca y a las casas de campo y sus alrededores.

La selección de una especie de árbol, para fines ornamentales parece ser tarea muy difícil para la mayoría de las personas, probablemente, por tener escasos conocimientos sobre la serie de factores que determinan las cualidades buenas o malas de las especies de árboles ornamentales o para sombra.

En la Isla se cultivan muchas especies de árboles que se dedican a fines ornamentales y para sombra, las cuáles, desde el punto de vista entomológico, patológico o por condiciones propias de la especie no son las más recomendables, constituyendo así, un error el cultivarlas. No sólo cometen ese error los desconocedores de la materia, sino también algunas personas con conocimientos agrícolas y aún alguna que otra agencia del gobierno .

El propósito de este breve artículo, es dar a cooncer un número de árboles que no deben sembrarse en Puerto Rico y al mismo tiempo recomendar aquellos que pueden ser de mayor beneficio al ornato de la Isla.

Arboles Que no Deben Sembrarse

Los siguientes árboles los considera el entomólogo indeseables para fines ornamentales o de sombra:

Cañafístula, *Cassia fistula* L.

Roble de plata, *Grevillea robusta* A. Cunn

Cassia amarilla, *Sciacassia siamea* (Lamb.) Britton

Maga, *Montezuma speciosissima* Sessé & Moc.

Flamboyán, *Delonix regia* (Bojer) Raf.

Tulipán africano, *Spathodea campanulata* Béauv.

Capá prieto, *Cordia alliodora* (R. & P.) Cham.

Roble blanco, *Tabebuia pallida* Miers

Laurel de la India, *Ficus nitida* Thumb.

Almendro, *Terminalia catappa* L.

Cedro, *Cedrela odorata* L., Cedrela mexica*na* Roem.

Acacia, *Albizzia procera* (Willd.) Benth.

Oreja de mono, *Enterolobium cyclocarpum* (Jacq.) Griseb.

Pino Australiano, *Casuarina equisetifolia* Forst.

Péndula, *Citharexylum fruticosum* L.

Madre de cacao, *Gliricidia sepium* (Jacq.) Steud.

Angela o Bén, *Moringa oleifera* Lam.

Alelí, *Plumeria alba* L., *Plumeria rubra* L.

Emajaguilla, *Thespesia populnea* (L.) Soland

Sin embargo, las especies, arriba mencionadas, son las que más se observan en las carreteras, jardines, parques y fincas privadas.

1/ Conferencio dictado como porte de un symposium de la Sociedod Americona de Ciencios Agrícolos, Río Piedras, Puerto Rico, celebroda el 14 de noviembre de 1952.

Las razones que existen en contra del cultivo de estos árboles, son las siguientes:

La cañafístula, el roble de plata, la cassia amarilla y la maga son especies muy susceptibles a los ataques de la queresa pustulosa, (*Asterolecanium pustulans* (Cockerell)). Esta queresa no sólo ataca los troncos y ramas, deformándolos y causando una fea apariencia en los mismos, sino que les causa la muerte, no importa el tamaño, ni lo desarrollados que estén. Este insecto atacó severamente al roble de plata en la Isla y causó la desaparición total de esta especie. El autor ha podido observar hileras de hasta 60 árboles de cassia amarilla, completamente destruídos por la queresa pustulosa. Hace años (6) se observaron muchos árboles de maga en el área entre Dorado e Isabela, los cuáles en su mayoría venían sucumbiendo a los ataques de este insecto.

El Dr. George N. Wolcott, Entomólogo de la Estación Experimental, ha notado que últimamente no han aparecido ataques o brotes infecciosos de la queresa pustulosa, pero hay que considerar que toda vez que el insecto está presente en la Isla, resulta sumamente arriesgado sembrar estas especies en grande escala. No se puede perder de vista la posibilidad de que ocurra en cualquier momento un brote o incidencia de este insecto y cause la destrucción de millares de árboles de las especies arriba mencionadas, como ya ha sucedido en el pasado.

El flamboyán es uno de los árboles más comunes en la Isla. Se encuentra en los patios y jardines y también en las orillas de los caminos y carreteras. El flamboyán en flor es un espectáculo impresionante como todo el mundo sabe, pero una vez que pasa este período, el árbol se torna poco atractivo, pués pierde sus hojas, y se llena de vainas secas. Entonces es cuando más se le notan los túneles y nidos del comején, lo que contribuye a afear su aspecto. Por ser esta especie muy susceptible a los ataques del comején común, (*Nasutitermes* (N) *costalis* (Holmgren)). Es raro el árbol de flamboyán que no sufra los ataques de este insecto.

También sufre frecuentemente de las depredaciones de un insecto defoliador. Se trata de la oruga, o larva de la mariposa nocturna, (*Melipotis acontioides* (Guenée), la cuál se multiplica rápidamente. El autor ha visto millares de árboles en el Valle de Lajas y en los alrededores de Guánica completamente defoliados por este insecto. Estas orugas atacan los árboles en número tal y con tanta voracidad, que pueden eliminarles las hojas a un árbol en menos de 12 horas. Fué en el año 1933 que se informaron casos de árboles atacados en el área del Condado y Hato Rey. El periódico "El Mundo", durante los últimos días del mes de agosto del 1933, dió un informe detallado sobre el ataque severo de esta plaga en los sitios mencionados y según fué informado por el Sr. Francisco Seín, Entomólogo de la Estación Experimental Agrícola.

El sistema de raíces del flamboyán es tan superficial que hace desventajosa su siembra como ornamental en los alrededores de las casas y aceras. Este árbol cuando se desarrolla normalmente, extiende sus raíces, casi siempre por sobre la superficie del terreno, causando así la rotura de las aceras, encintados, verjas de concreto y hasta de las paredes de las casas. La única bondad de esta especie, su bella florecida, se aminora cuando se consideran todas sus desventajas.

El tulipán africano no ofrece inconvenientes, desde el punto de vista entomológico, ya que los pocos insectos que lo atacan, ninguno causa daños de mayor importancia que puedan restarle méritos a la belleza de este árbol. Sin embargo al igual que el flamboyán, tiene un sistema de raíces, quizás muy superficial, y por lo tanto tampoco es recomendable para sembrar cerca de las residencias, aceras o verjas de concreto. De haber espacio disponible, el tulipán africano puede ser una de las especies para ornato y sombra más recomendables para Puerto Rico.

El capá prieto, es un árbol de gran utilidad, no sólo por la excelente calidad de su madera que se prefiera para la construcción de muebles finos, sino por la belleza de sus ramilletes de flores blancas enmarcadas en

el fondo verde obscuro del follaje. Es de admirar los capás prietos de las cercanías del Peñón del Collao entre 1,800 y 2,300 pies de altura, en la carretera de Cayey a Salinas cuando están en flor. A pesar de su extrema belleza no es recomendable como ornamental o para sombra por ser atacado, desgraciadamente, por una chinche de ala de encaje. Esta chinche, (*Monanthia monotropidia* Stal) no sólo descolora el follaje, sino que eventualmente causa la caída de las hojas. El ataque es constante, pues las generaciones del insecto se suceden sin cesar. Sin embargo puede ser un buen árbol de madera, si se siembra conjuntamente con otras especies en los bosques o fincas de café.

El roble blanco y su especie hermana, el roble prieto (*Tabebuia heterophylla* (DC.) Britton) se usan en Puerto Rico como árboles ornamentales y de sombra. Se pueden observar generalmente en los patios, jardines, y calles de las ciudades y pueblos de la Isla. El roble blanco muy común en las montañas de la Isla, es una de las especies más vistosas durante su florecida. Todo el árbol se cubre de un manto de flores, las cuáles varían del color rosa pálido hasta el rosa subido. Las flores al caer, forman una alfombra alrededor del árbol y la combinación de flores en las ramas y sobre el suelo resulta muy agradable a la vista del viajero.

La enfermedad, "escoba de bruja" ataca al roble blanco. De acuerdo con las investigaciones del Dr. M. T. Cook (*3*) quién estudió esta enfermedad, la misma es causada por un virus, cuyo posible vector es el saltón de las hojas (*Protelebra tabebuiae* Dozier). Un árbol que sufra severamente de esta enfermedad pierde toda su belleza y se convierte en un manojo de escobillas, lo que no es lo mejor para el ornato. La enfermedad prevalece mayormente en los árboles de roble que crecen en los terrenos llanos.

También, durante las épocas de sequía, los saltones de las hojas se alimentan del follaje de los robles, causándoles una clorosis o amarillez a las hojas. Llega el momento en que las hojas se desprenden y el árbol se queda completamente defoliado. Cuando los ataques de este insecto coinciden con la "escoba de bruja", el árbol cobra un aspecto por demás indeseable.

Esta especie podría substituirse por el roble de plata, (*Tabebuia argentea*) o por el roble amarillo (*Tabebuia glomerata* Urb. Poui) que son inmunes a la "escoba de bruja."

El laurel de la India es un árbol favorito de las plazas y parques, pues es corpulento y ofrece excelente sombra. Es una de las especies menos recomendables para la Isla. Sus hojas sucumben al trípido o candelilla (*Gynaikothrips ficorum* (Marchal), que es un insecto de reproducción rápida especialmente durante los largos períodos de la sequía. Deforma las hojas y las enrosca con preferencia a las de los retoños o tallos tiernos. Dentro de las hojas así enroscadas, viven estos pequeños insectos que al más leve movimiento se dejan caer muchas veces en los ojos de los transeúntes, para causarles una gran irritación, con el mismo efecto de una chispa de candela o de gotas de alcohol. Miles y miles de estos pequeños insectos vuelan o los lleva el viento de árbol en árbol. Este árbol no debe sembrarse en los parques de recreo, ya que el insecto que se alberga en el mismo es nocivo.

Podría substituirse por otra especie del mismo género, el *Ficus benjamina* L., que es completamente inmune a los ataques del trípido o candelilla. Habría entonces, que propagar esta última especie de material aclimatado a la Isla pués se sabe que en Santo Domingo esta especie alberga otra especie de trípido muy parecido al que ataca aquí al laurel de la India y podría introducirse a nuestro país ese indeseable insecto. También se podría substituir el laurel de la India, por el palo de pollo (*Pterocarpus officinalis* Jacq.) El *Pterocarpus* es un árbol que se asemeja mucho al laurel y es resistente a las enfermedades e insectos. Produce muy buena sombra y adquiere gran tamaño lo cual, lo hace muy adecuado para los parques y residencias.

Las otras especies de *Ficus* que existen en la Isla son inmunes al trípido. Pueden sembrarse en lugar del *Ficus nitida*.

El almendro y el cedro son dos especies indeseables como árboles de sombra u ornato.

El almendro lo ataca un trípido o candelilla (*Selenothrips rubrocinctus* (Giard), generalmente durante los meses del otoño y del invierno. El insecto se multiplica rápidamente, ataca las hojas tornándolas amarillentas algunas y plateadas o blancuzcas otras, y finalmente deshoja todo el árbol. Debido al incesante ataque de este insecto el árbol de almendro se queda, la mayor parte del tiempo, sin hojas y por lo tanto sus funciones como árbol de sombra resultan nulas.

Lo mismo le ocurre a los cedros cuando estos son atacados por el saltón de las hojas (*Dikraneura cedrelae* Oman). Los ataques son consecutivos perdiendo el árbol toda su belleza. El cedro es un magnífico árbol de buena madera, pero no tiene valor ornamental, debido en gran parte al ataque de esta plaga.

La acacia y la oreja de mono a pesar de ser magníficos árboles ornamentales y de sombra, son susceptibles a una enfermedad muy parecida al "mal de la guaba". El Sr. L. Alvarez García (*1*) Fitopatólogo de la Estación Experimental, estudió esta enfermedad, causada por el hongo, *Fuscrium oxyosporum* var. *perniciosum*, raza 2. El autor notó una enfermedad similar durante el mes de junio del 1952 en árboles de oreja de mono, en los alrededores del Hospital de Distrito de Bayamón.

Esta enfermedad produce una abundante exudación de un líquido amarillento por las rajaduras de la corteza del tronco de las ramas de los árboles enfermos. Ataques secundarios de insectos de la corteza y del tronco tales como cermabícidos, bupréstidos y escolítidos siguen a la enfermedad. Estos ataques contribuyen a destruir el árbol que, finalmente, en el momento menos esperado, se cae. Si el árbol padece de la enfermedad es recomendable cortarlo inmediatamente. Así se evitará la propagación de la enfermedad a los árboles vecinos. En las cercanías del lago del Guayabal, en Villalba, el autor observó una enfermedad similar en el flamboyán.

El Sr. Alvarez García recomienda el uso de otra especie de acacia, la *Albizia lebbeck* (L.) Benth., por que es resistente a la referida enfermedad. Durante los últimos años, el autor ha observado numerosos árboles de esta especie que han sido atacados y destruídos por la enfermedad, en el área de Río Piedras a Guaynabo y también en Villalba.

Debido a la susceptibilidad de los anteriores árboles a las enfermedades mencionadas no es recomendable su siembra.

El pino australiano se usa mucho como árbol ornamental en la Isla. Existe una enfermedad desconocida hasta la fecha, que destruye los árboles de esta especie estando aún bien desarrollados. Durante los años 1940 y 1941 muchos árboles de *Casuarina* enfermos tuvieron que ser destruídos para evitar que cayeran sobre las casas y plantíos de caña. La enfermedad se parece mucho a la de la acacia y oreja de mono, e igualmente la *Casuarina* sufre de los ataques secundarios de insectos taladradores de la corteza y el tallo, después de tener la enfermedad.

El uso del pino australiano con fines de sombra permanente puede limitarse debido a esta enfermedad, aún no estudiada. Esta especie puede sembrarse para otros fines, tales como para obtener espeques, largueros para ranchones, etc., donde el árbol se corta por lo regular antes de llegar a su madurez.

La péndula se siembra en las orillas de las carreteras y en algunos jardines. La larva de una mariposa (*Pyrausta cerata* (Fabricius) ataca el follaje de este árbol. Esta larva u oruga, forma unos mazos o manojos de hojas, las cuáles pegan unas con otras. Cuando las hojas se secan, el árbol queda finalmente desnudo. El árbol, algunas semanas después, adquiere nuevo follaje, pero si las condiciones son satisfactorias, el insecto vuelve a infestar de nuevo al árbol. El aspecto de un árbol de péndula bajo el ataque de este insecto no ayuda en nada al ornato.

La madre de cacao es uno de nuestros árboles ornamentales más útiles. Su flor se asemeja mucho a la de los cerezos japoneses, ya que es rosada o violácea y se adhiere a las ramas y al tronco. El follaje sin embargo, lo ataca un áfido o pulgón, (*Aphis medicaginis* Koch.), el cuál se propaga rápidamente cubriendo grandes áreas e infestando cientos de árboles. El líquido dulce que segrega este pulgón, no sólo atrae a las hormigas sino también a una clase de hongo negro, conocido por hollín. Las hojas se cubren con este hongo negro y muchas se caen. En general, el aspecto en este estado resulta lúgubre. Cuando se estacionan automóviles debajo de los árboles atacados por el pulgón, todo el carro se cubre del líquido dulce segregado por los pulgones. Esto lo han sufrido los que estacionan automóviles bajo estos árboles en los terrenos de las casetas de la PRRA en Puerta de Tierra.

Tanto los árboles que se encuentran en las alturas de la Isla, como también en las llanuras, son atacados por este insecto. Su siembra como ornamental no debería continuarse.

El angela o ben se siembra a las orillas de las carreteras y en muchos jardines, en el sur de la Isla. El árbol en flor es muy atractivo y su fruto es una vaina larga muy vistosa. Esta especie es muy susceptible a los ataques del comején, y sus túneles se encuentran en todas las ramas ,tronco y hasta en las vainas secas del árbol. Este adquiere una apariencia muy pobre. Su susceptibilidad a los ataques de este insecto tan común, lo hace indeseable como ornamental.

Los alelíes son arbustos ornamentales que se siembran usualmente en los jardines y patios de las residencias. Sus flores blancas y rosadas son muy bonitas. Una oruga negra con franjas amarillas o cremosas, con la cabeza y parte porterior rojas ataca el follaje de estos árboles. La oruga adquiere un tamaño considerable, a veces hasta de 6 pulgadas de largo. Es muy voraz y causa la completa defoliación de los árboles atacados. En muchas partes de la Isla el insecto persiste en sus ataques constantes y hace al árbol poco deseable como ornamental.

La emajaguilla o Santa María se encuentra en las orillas de las carreteras y en muchos patios en las residencias por todo el sur de la Isla. Pertenece a la familia Malvaceae, igual que la maga y se considera planta hospedera de la oruga rosada de la cápsula del algodón. La emajaguilla y la maga deben ser eliminadas totalmente del área algodonera de Puerto Rico. En estudios verificados por el autor (*4*) en el área algodonera del norte de Puerto Rico, se demostró que la presencia de gran cantidad de árboles de maga y emajaguilla contribuían a mantener un alto promedio de infestación de la oruga rosada de la cápsula del algodón (*Pectinophora gossypiella* Saunders) en los algodonales comerciales.

La emajaguilla es también la principal planta hospedera de los manchadores de la fibra del algodón (*Dysdercus andreae* (L.) y *D. sanguinarius* Stal). Estos insectos, aunque no causan en Puerto Rico daños de importancia económica al algodón, en cualesquier momento pueden constituir una amenaza para la industria algodonera.

Las especies de árboles arriba mencionados, le dan una idea al lector de los errores que se cometen a diario en Puerto Rico cuando se siembran árboles en las carreteras, caminos, patios, parques, jardines, etc., sin antes estudiar detenidamente sus cualidades buenas o malas.

Arboles Propios para Sombra y Ornamentación

Actualmente tenemos aquí, infinidad de especies nativas e importadas que sirven perfectamente para ornamentar y dar sombra a nuestras carreteras y residencias, sin los inconvenientes que poseen las especies arriba mencionadas.

La lista sería bastante extensa, pero para abreviar citaré las especies más comunes y más adaptables a nuestro clima tropical. La lista incluye el nombre común en

español, igual que el nombre técnico de cada árbol. En la tercer columna se indican los usos y fines para los cuáles pueden utilizarse los árboles.

Nombre Vulgar	Nombre Científico	Usos [2]
Aceitillo	*Zanthoxylum flavum* Vahl	SM
Achiote	*Bixa orellana* L.	SF
Alelaila	*Melia azedarach* L.	O
Algarrobo	*Hymenaea courbaril* L.	SM
Anacaguitas	*Sterculia apetala* (Jacq.) Karst.	SO
Ausubo	*Manilkara bidendata* (A.DC.) Chev.	SM
Bala de cañón	*Couroupita guianensis* Aubl.	O
Bálsamo de cayeput	*Melaleuca leucodendron* L.	SO
Bayahonda	*Prosopis juliflora* (Sw.) DC.	SO
Bucayo	*Erythrina glauca* Willd.	SO
Bucayo enano	*Erythrina berteroana* Urban	SO
Bucayo gigante	*Erythrina poeppigiana* (Walp.) O. F. Cook	SO
Burro	*Capparis coccolobifolia* Mart.	SO
Burro blanco	*Capparis portoricensis* Urban	SO
Burro prieto	*Capparis cynophallophora* L.	SO
Cañafístula cimarrona	*Cassia grandis* L. F.	SO
Caoba de Honduras	*Swietenia macrophylla* King	SM
Caoba dominicana	*Swietenia mahagoni* Jacq.	SM
Caoba venezolana	*Swietenia candollei* Pittier	SM
Cassia rosada	*Cassia nodosa* Hamilt.	O
Cerezo o muñeca	*Cordia nitida* Vahl	SO
Cóbana	*Stahlia monosperma* (Tul.) Urban	SM
Cojoba o cojóbana	*Pithecolobium arboreum* (L.) Urban	SO
Coco marino	*Barringtonia speciosa* Forst	SO
Cupey	*Clusia rosea* Jacq.	O
Dilenia	*Dillenia indica L.*	SO
Emajagua	*Pariti tiliaceum* (L.) Hil.	O
Eucalipto oloroso	*Eucalyptus citriodora* Hook	O
Eucalipto	*Eucalyptus robusta* Smith	SO
Genogeno	*Lonchocarpus domingensis* (Pers.) DC	SO

2/ En esta columna por medio de símbolos clasificaremos los árboles según sus usos más comunes. Para otros usos y fines particulares consúltese la obra del autor. Véase bibliografía (3). S—sombra; M—madera; F—fruta; O—ornamental, ya por sus flores, frutas o apariencia del árbol.

Nombre Vulgar	Nombre Científico	Usos
Geno	*Louchocarpus glaucifolius* Urban	SO
Goma	*Castilla elastica* Cerv.	SO
Granadillo	*Buchenavia capitata* (Vahl) Eichl.	O
Guara	*Cupania americana* L.	SO
Guaraguao	*Guarea trichilioides* L.	SM
Guamá	*Inga laurina* (Sw.) Willd.	S
Guamá americano	*Pithecolobium dulce* (Roxb) Benth	SO
Guano	*Ochroma lagopus* Sw.	O
Guasávara	*Eugenia aeruginea* DC	SO
Guayacán	*Guaiacum officinale* L.	SOM
Guayacán de vera	*Guaicum sanctum* L.	O
Ilán-ilán	*Canangium odoratum* (Lam.) King	O
Jácana	*Lucuma multiflora* A. DC.	SO
Jagua	*Genipa americana* L.	SOF
Jagueyes	*Ficus benjamina* L.	SO
"	*Ficus Stahlii* Warb.	SO
"	*Ficus sintenisii* Warb.	O
"	*Ficus laevigata* Vahl.	SO
"	*Ficus lyrata* Warb.	SO
"	*Ficus nekbuda* Warb.	SO
Javillo	*Hura crepitans* L.	SO
Mago	*Hernandia sonora* L.	SO
Laureles	*Ocotea* y *Nectandra* spp.	SOM
Malagueta	*Amomis caryophyllata* (Jacq.) Krug & Urban	SO
Mamey	*Mammea americana* L.	SOF
Mango	*Mangifera indica* L.	SF
Manzana malaya	*Jambos malaccensis* (L.) DC.	SOF
María	*Calophyllum calaba* Jacq.	S
Maricao	*Byrsonima spicata* (Cav.) DC.	SO
Mariposa	*Caspareopsis monandra* (Kurz) Britton	O
Mesquite	*Prosopis glandulosa* Torrey	S

Nombre Vulgar	Nombre Científico	Usos
Moca	*Andira jamaicensis* (W. Wright) Urb.	SOM
Moral	*Cordia sulcata* DC	SO
Palo de doncella	*Byrsonima cuneata* (Turcz.) P. Wilson	SO
Palo de pollo	*Pterocarpus officinalis* Jacq.	SO
	Pterocarpus indicus Willd.	SO
Pana	*Artocarpus communis* Forst.	SOF
Peronía	*Ormosia krugii* Urban	SO
Pana cimarrona	*Artocarpus integrifolia* L.	SO
Pomarrosa	*Eugenia jambos* L.	SOF
Quenepa	*Melicocca bijuga* L.	SF
Reina de las flores	*Lagerstroemia speciosa* (L.) Pers.	SO
Resedá	*Lawsonia inermis* L.	O
Roble amarillo	*Tecoma stans* (L.) H.B.K.	S
Rosa de maximiliano	*Maximilianea vitifolia* (Wild) Krug & Urb.	O
Samán	*Samanea saman* (Jacq.) Merrill	SO
Sapota de costa	*Manilkara pleena* (Pierre) Cronquist	S
Sauce	*Salix chilensis* Molina	O
Sisso	*Dalbergia sissoo* Roxb.	SO
Tamarindo	*Tamarindus indicus* L	SOF
Teca	*Tectona grandis* L.	SOM
Triplaria	*Triplaris caracasana* Cham.	SO
Ucar	*Bucida buceras* L.	SOM
Uva de playa	*Coccolobis uvifera* L.	OF
Vomitel colorado	*Cordia sebestena* L.	O
Yagrumo macho	*Didymopanax morototoni* (Aubl.) Dcne & Pl.	O

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The Tropical Rain Forest [1]

A REVIEW

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It is a pleasure to record the appearance of an impressive volume which at once takes its place in the field of vegetation study. This book will serve the technical reader for an authoritative and well-balanced source of reference, even as it will serve the lay public for an interesting and readable account of a forest region which holds an unequalled facination. In so many ways does this volume allow us new, and rather overdue, perspectives on the scattered literature of the tropical rain forest and in turn set the stage for new developments, that I feel it worthy of extended consideration. Certainly an intensive perusal is essential for all temperate ecologists who are striving to formulate a science of world-wide applicability.

The author approaches his subject with laudable modesty. His "main qualification for such a formidable task is first-hand experience of rainforest vegetation adding up to nearly two years", but extending through 7 years in Borneo, British Guiana, and Nigeria. He admits this qualification is "painfully inadequate". Although examples from these three territories are perhaps too constantly brought to the attention of the reader, the "inadequacy", if such it is, is more than amply compensated by a remarkable grasp of the tropical rain forest literature, the integration of which is the volume's chief contribution. In this literature, the author has ranged widely, apparently in complete disregard of the languages involved and in a manner that would be difficult for most Americans.

This volume is dedicated to the memory of Carl Schroeter, and thus is expressed the root of its author's approach to the study of vegetation. To many of us, the book is a lineal descendant of the tropical rain forest sections of Shimper's Pflanzengeographie, brought up to date in facts and concepts. Relegated to the past, with barely an excuse for their omission, are the discussions of far-fetched "adaptations" and teleological interpretations, ideas which though "scientific" in their heyday now seem to us more akin to that earlier era when "natural philosophy" was often undertaken to reveal and to marvel at the glories of God, and to discover the uses for man of all his creations, uses which he seemed adept at hiding from the creature for which he created them. The author claims to follow the general principles of the Anglo-American school of ecologists. We appreciate this fraternal hand-clasp across the North Atlantic, certainly expressed in good faith. Actually however, the American influence is obviously at a minimum throughout the book, and where it is apparent (as in discussions of climate climax, and of monoclimax versus polyclimax) it appears strangely irrelevant, almost like an atheist saying grace at table when dining with theologians. Words like consociation, association and formation are frequently in quotation marks, implying only usages of the authors he quotes. An "etum" is mentioned but once. Such elastic terms as "primary", "community" and "single-dominant" are used and preferred. True, he does use the term climatic climax, but unobjectionably, in general reference to virgin or primary vegetation. In only one instance does he attempt a definition, and that one sentence pinpoints precisely the irrationality and illogic of the argument: "The English school of plant ecologists have compromised between the Monoclimax and Polyclimax theories of vegetational development by regarding one climax formation in each climatic region (that found on the most wide-spread or 'normal' combination of soil and

[1] Richards, P. W. 1952. The tropical rain forest, an ecological study. Cambridge University Press. New York and London. 450 pp.

topography) as the climatic climax and others in the same region as edaphic or physi ographic climaxes." In short, the sole criterion for raising the one virgin and primary community to the dignity and superiority of the climax climax, and for debasing all the others to the stigma of inferiority and immaturity, is the completely arbitrary one of which occupies the most area and thus which is "normal" (democracy-with a vengeance). I suspect furthermore that if the vote is a tie, we all would be astrongly influenced by which community subjectively impresses us the most with its lushness, floristic complexity and simple American bigger-ness and better-ness. If this policy were to be adhered to strictly, I maintain that if one deals, e.g., with areas of shrub-covered rocky cuestas, and grass-covered horizontal strata, and if these two landforms occur areally in all proportions, then the edaphic shrub climax would become a climatic climax (with all implications of different climate, and of climax soil) wherever we step over such a political or other boundary that the relative area changes from 49 to 51 percent. We need not leave this country to find many such examples.

Dr. Richards' volume concerns all the tropical rain forests of the world, which he recognizes as related in many and various ways, ways customarily lumped under the term "ecological". He recognizes their division into three formations, the American, the African, and the Indo-Malayan, differentiated in terms of their floras. It is upon differences and similarities between these three territories that the book is constructed. It was not the intent to describe the forests of smaller areas, country by country. Many will be disappointed that the Hawaiian islands were purposely omitted from discussion, for even though they are the farthest outpost of the Indo-Malayan tropics, their abundant literature is time and again apropos of the arguments he develops.

The volume is divided into five parts, each composed of separate chapters. Part I, "Structure and Physiognomy" includes discussions of synusiae (not communities, but floristic aggregates of plants similar in their carbohydrate requirements, like epiphytes, and saprophytes), and of stratification (which he finds universally to tend to three layers of trees, not more). Profile diagrams are included, a graphic technique which Dr. Richards has developed, the original suggestion for which he credits to Sir Edward Salisbury, and which certainly deserves further application, in temperate regions as well. The chapter on regeneration (a matter of functions, rather than of structure) has much of general interest in the data on age-class representation, the death of one tree or small groups, and development in the resulting gaps. Aubreville's Mosaic Theory is here discussed, which should crystallize for many what may have been but vaguely perceived. The theory refers to a dynamic equilibrium, a constancy-in-change, on a time-scale and a space-scale much greater than most of us are inclined to adopt. Spot-wise on the land, this means a succession of combinations of dominant species. This approach certainly deserves consideration even beyond Dr. Richards' regional discussion of it. The theory may well embrace what in certain temperate climates has been simplified and distorted into a 2-phase cycle of conifers and hardwoods. And where the flora is somewhat more complex, it may include what has been called an "association segregate" (though such a segregate would not then have the continuous historical community-phylogeny overtones). Furthermore, it seems to this reviewer that such an approach to the interpretation of a large forest region has always been the viewpoint of those who recognize that there are species which are effective ecological equivalents, especially with complex floras, and that matters of chance and coincidence are operative in vegetation —the niceties of ecological theory notwithstanding. This Part I also includes discussions of such physiognomic features as bark, buttresses, neumatophores, leaf shapes, and special features of flowers and fruits. The last chapter is concerned with the ground layer herbs, and the various synusiae.

Part II, "The Environment" has separate chapters on climate, microclimates, seasonal changes and soil conditions. In the preface, Dr. Richards indicates that the absence of a discussion of biotic factors is due only to the lack of available data. What new insights and outlooks we may anticipate when we will have progressed beyond the present edapho-climatic determinism! One thinks of the high-altitute supra-mossy-forest grasslands of New Guinea, once thought to be a climatic climax, but eventually recognized as a favored home of the wallaby, who was hunted by the indigenes, who burned the vegetation, who left the region —but the vegetation lingered on. Perhaps that type of "climatic climax" is not so unusual. The chapter on soils will be welcomed by many for whom the complicated and conflicting literature has been a stumbling block. Dr. Richards leaves us with the impression that relatively little is known (though soil scientists have a most impressive and complicated way of saying that little). Of one thing we all feel more sure, that for a region which has had aeons of time to approach a single homogeneous end-stage, there are remarkable and striking diversities, involving contrasting lateritic and podzolic processes, reflected with equal diversity in their respective vegetations. He quotes one discontinuum that should end all arguments for the universality of continua. This occurred in British Guiana, where the division between the white-soil wallaba forest and the brown-soil greenheart forest clove the fresh soil of an ant-hill, with the two appropriate trees, last representatives of their respective communities, growing out of the sides, so close to each other that one had to turn sidewise to slip between the two communities.

Part III discusses the "Floristic Composition of Climax Communities", based on sample plot data from the literature. Some readers will be surprised at the relatively numerous examples of single-dominant primary communities in the tropics. On the other hand, data from the "mixed communities" only emphasize the high degree of their mixedness, and make us realize that most of our association concepts would not have arisen in the tropics, and cannot be applied in the tropics.

Part IV, "Primary Succesions" is composed of three chapters. The first is on the primary xerosere, almost entirely an excellent review of the recolonization of Krakatau. The second, on hydroseres, points up a general pan-tropical development that bears many similarities to the development in temperate regions, with two trends, for eutrophic waters, and for peat-accumulating oligotrophic waters. I would have liked to have seen a discussion here of the principle exemplified by our own Everglades, where the erosive force of water movement is insufficient to offset the development of peat, and thus an upland can be succeeded by a swamp. The third chapter on coastal successions is a brief treatment of sandy-shore vegetation, and a more extended discussion of mangrove vegetation (thankfully with no comments whatever on the seedlings so prefectly "adapted" to plunk into the mud below). It is here that I feel that the American influence has been unfortunate. A belting of vegetation types in space is not ipso facto reason for considering them successions in time. In this instance I have a personal knowledge of the South Florida conditions he describes in detail. The field evidence appears to indicate that the belts are distinctive site types, and that if a succession must be assumed, it is related to a gradually rising sea level. The elaborate succession diagram would then be acceptable —if all the arrows were reversed. Certainly there is development within any one belt, but the one example of his quoted author that actually suppports the succession theory, puzzles that author, and he leaves it as an anomaly.

Part V, "Tropical Rain Forest under Limiting Conditions" is an impartial documented review of the literature, in two chapters. The first concerns those studies that include, in addition to rain forest, other vegetation types variously called monsoon forest, savanna forest, thorn forest, savanna, and

desert. (Dr. Richards neither proposes nor adopts any system of classification for tropical vegetation types). His conclusions will come as a surprise only to those who have kept to the older books, and who are loth to part with the older theories. He states that "there is no such thing as a 'tropical grassland climate', and that apparently all lowland tropical grasslands are due to anthropic or very local edaphic conditions. Evidence exists everywhere for the recognition of one or more "montane" forests on tropical mountains, although I looked in vain for an elaboration of the idea that Chipp used in his discussion of the Gold Coast Forest (and which is inherent in many ideas of vegetation relationships), that some of the vegetation types adjacent to the rain forest are composed of species occurring, but rarely, in that rain forest, and emerging into dominance where freed from competition of the other trees.

Part VI, "Man and the Tropical Rain Forest", is meant only to introduce a field worthy of a separate volume. It contains nevertheless a good summary of the vegetation developments on the lands of shifting agricultures. Here too the general picture emerges that although grasslands receive an impetus from fires and can become relatively stable, the forest will again take the land if fires are eliminated.

In a postscript on "The Future of the Tropical Rain Forest", the author paints an alarming picture of the tremendous acceleration with which these forests are being destroyed. In commenting on the effects of this destruction he indicates that it "has changed fundamentally the future course of plant evolution, and closed many avenues of evolutionary development", since the tropics have served as a centre of evolutionary activity for the entire world. Such a viewpoint would be opposed to Edgar Anderson's documented thesis that this very destruction has hybridized the habitats, and may well result in evolutionary outbursts to fill the new vacuum. As another consequence, the author mentions, but does not deal with the controversial subject of the effects on macro-climate. One might wish he had applied his knowledge to this field, for the known data, though fragmentary, are not only of great academic interest, but of high economic importance. He closes with a rational and eloquent plea for preservation of more such extensive areas as the Albert National Park in the Belgian Congo, areas to serve for needed an important biological research in the present, and for the study and admiration of future generations.

Thus we come to the end of this praiseworthy contribution to knowledge of the world's vegetation. Its author is the first to say that it is destined to be superseded as new information casts new lights. "No better prospect for. . . (his) work can be wished than that it may soon become out of date". When so, it will only move sidewise to a favored niche in history. In the meantime, like the dwarf of Didacus Stella, we can scramble to the giant's shoulders, complacently sweep the new horizons, and peer into the distance with considerable self-satisfaction at the ease with which we think we can see one mite farther.

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